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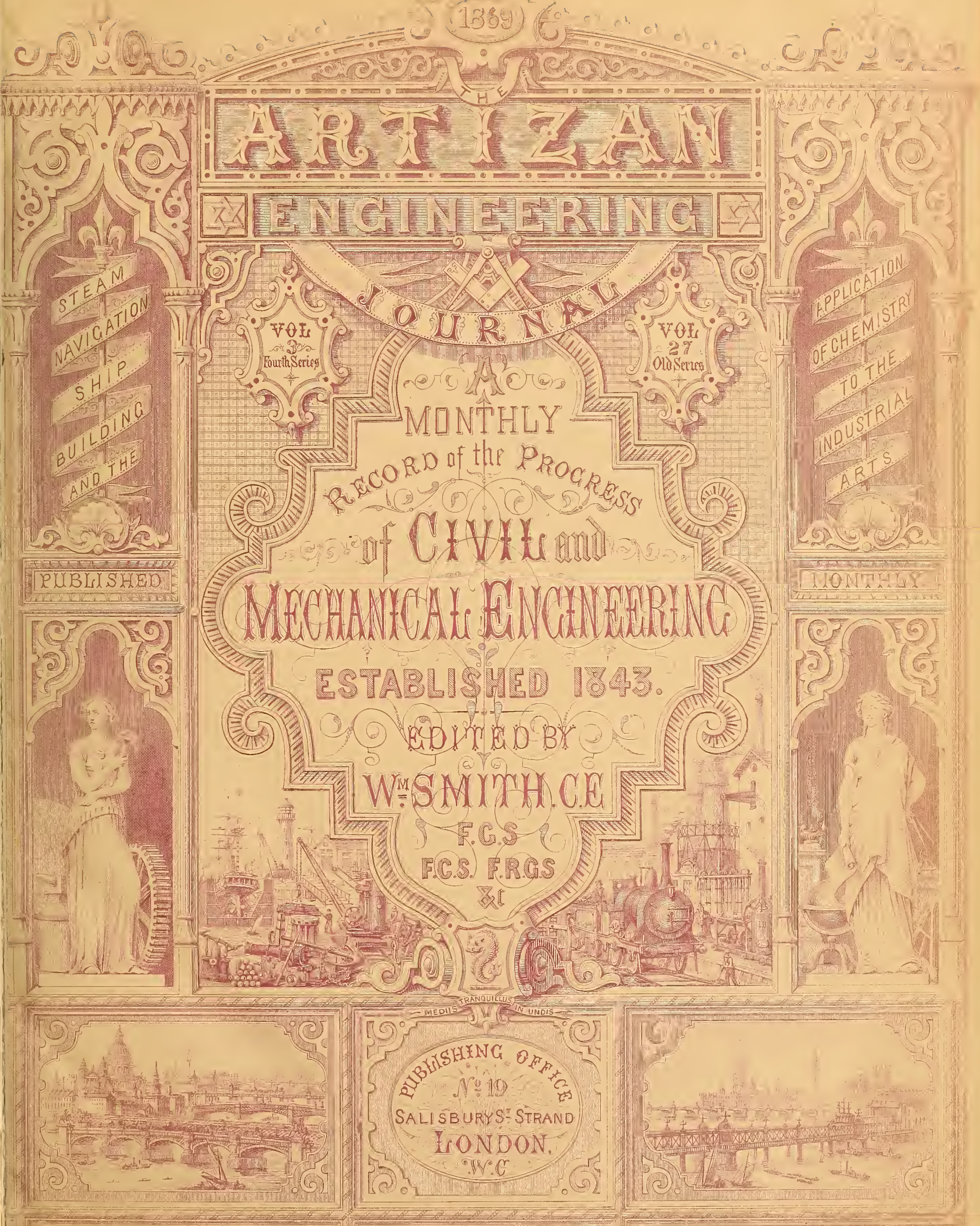

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Wm. SMITH, C.E.
F.G.S.
F.C.S. F.R.G.S.
&c

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# A. MORTON'S PATENT EJECTOR CONDENSER

*BY MESSRS NEILSON BROTHERS, ENGINEERS,*

ALBERT WORKS, GLASGOW.

Fig.1.

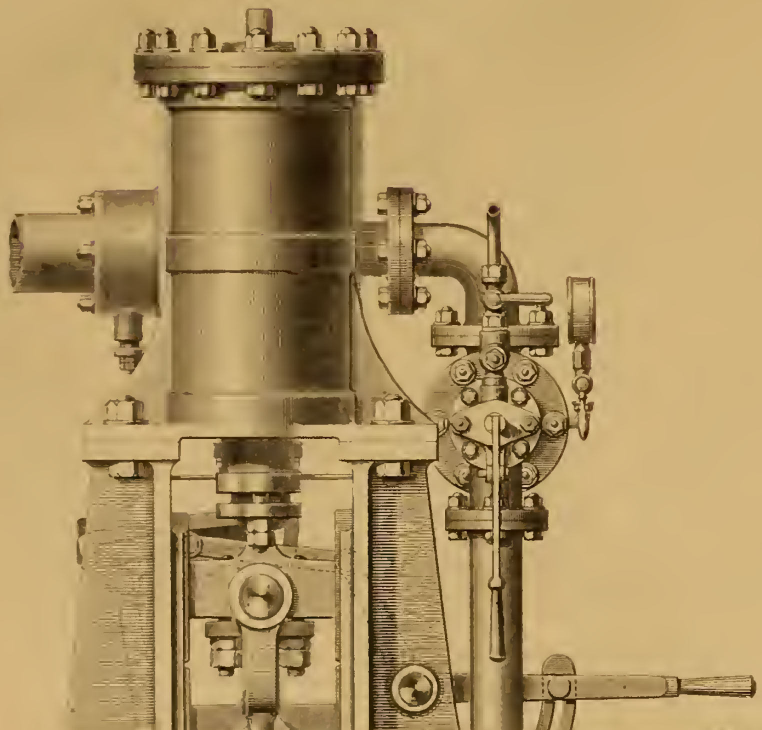


Fig.2.

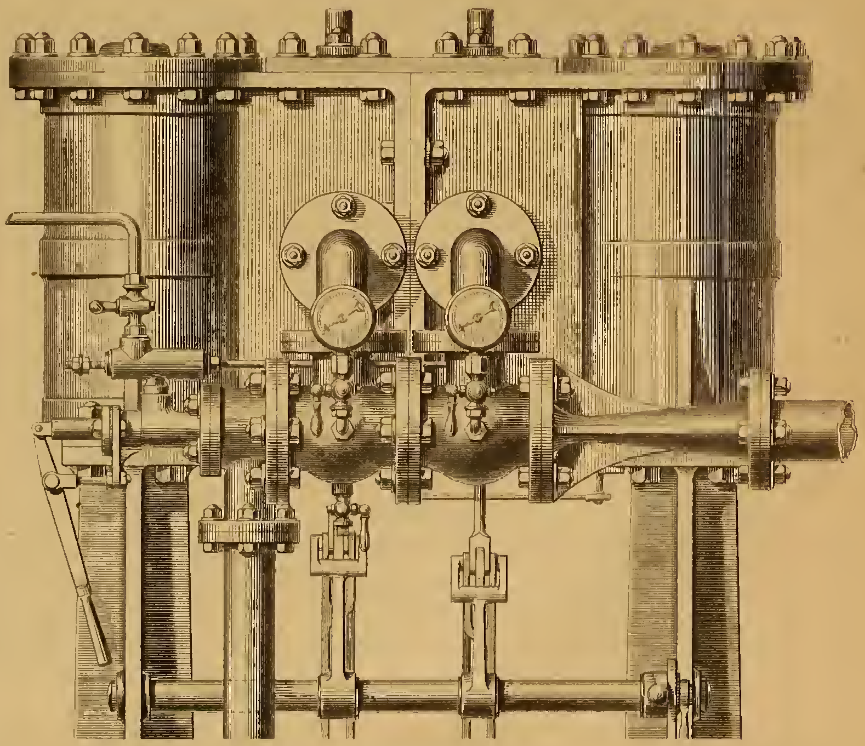


Fig.3.

SECTION THROUGH CONDENSER

*Scale to Fig 3 2in = 1 Foot*

W. Smith C.E. lith

# A. MORTON'S PATENT EJECTOR CONDENSER

*BY MESSRS NEILSON BROTHERS ENGINEERS*

ALBERT WORKS, GLASGOW

FIG. 1

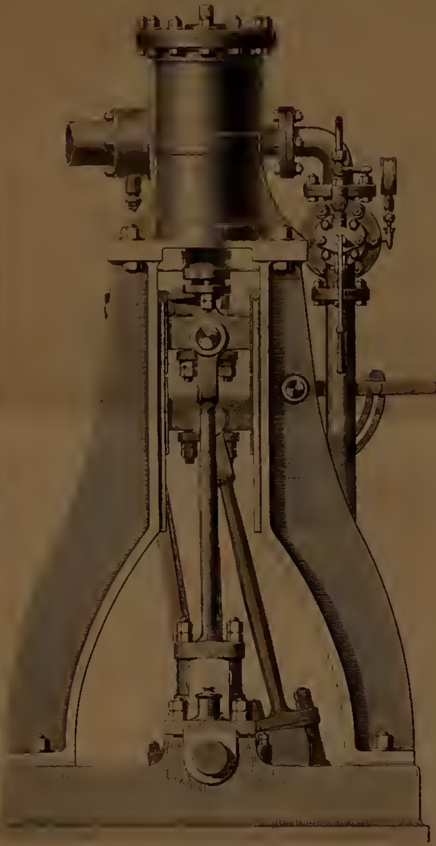
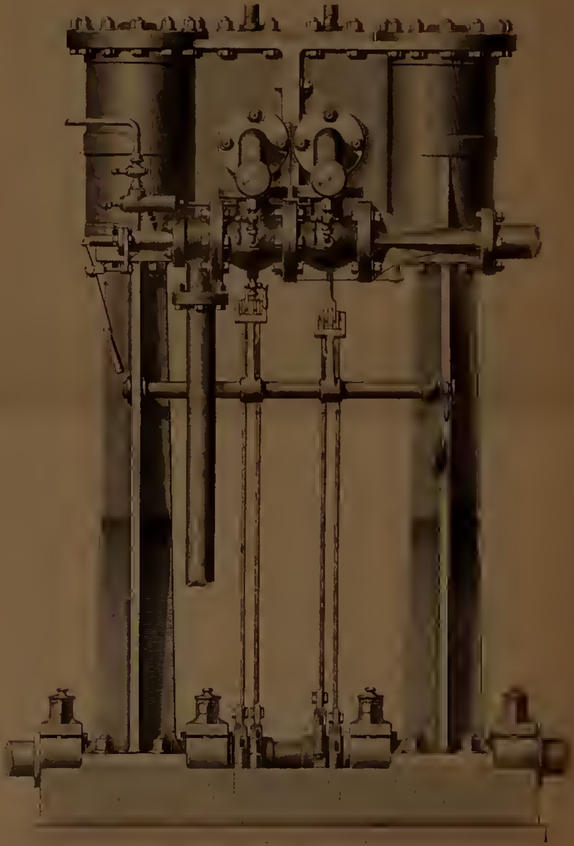


FIG. 2



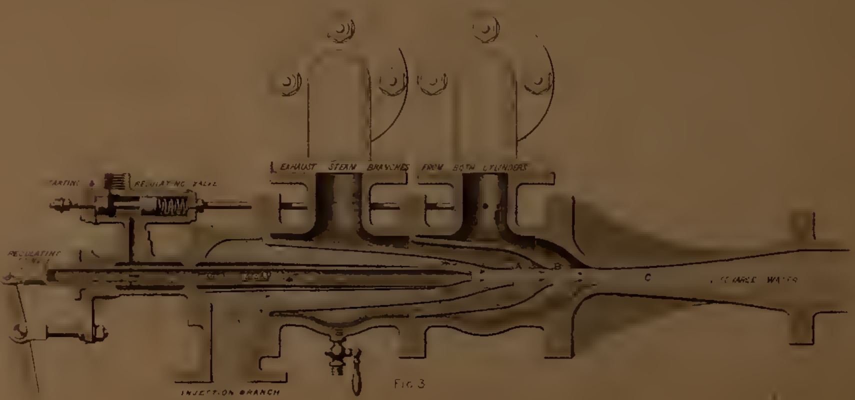

STARTING & REGULATING VALVE
REGULATING
EXHAUST STEAM BRANCHES FROM BOTH CYLINDERS
A
B
C
DISCHARGE WATER
INJECTION BRANCH

FIG. 3

SECTION THROUGH CONDENSER

# THE ARTIZAN.

No. 1.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. JANUARY, 1869.

## ARTIZAN ADDRESS.

Contrary to all expectation, the excessive depression existing in all departments of engineering at the time of the issue of our last address, has continued with unabated, if not, increased intensity. A stagnation of nearly three years duration, with but faint prospect of any considerable improvement is by no means pleasant to contemplate, but engineers are not as a rule a desponding class, and even now some are sanguine of "good times coming" very shortly, and we sincerely trust they may be right.

During the past year but few novelties have appeared, and both as regards science and practice, engineering may almost be said to have stood still. There are, however, a few exceptions to this rule, some of which have been already noticed in the Artizan. Thus, the extraordinary proposal of Mr. John Elder, the well-known ship-builder of Glasgow, to employ enormous circular iron-clad vessels capable of travelling at a high speed and of manoeuvring in every possible manner, was at first sight sufficiently startling. Upon examination however, as might be expected of the proposition of such an eminently practical man as Mr. Elder, the idea, as has already been pointed out in these columns, is found to be by no means so chimerical as it appeared, though of course it is not to be imagined that the Admiralty would for a moment entertain anything so perfectly novel. The substitution of liquid fuel for coals has attracted considerable attention during the past year, and bids fair to become a still more prominent topic than it is at present. The great difficulty to be overcome, has always been to effect the perfect combustion of the liquid, but this it appears has now been satisfactorily performed by several different methods. Of all the various schemes for effecting this purpose, the invention of Mr. Aydon appears to be the most effective, and by far the simplest. The results recorded in The Artizan of last year, p. 150, show an immense economy in fuel obtained by this system, and we understand the boilers there mentioned are still being worked with equally satisfactory results. The very high evaporative power there shown, has been disputed by some as a theoretical impossibility, but as that is based upon the assumption that the steam employed in connection with the liquid fuel only acts mechanically, it seems far more likely that the theory should be incorrect than a set of carefully conducted experiments. We certainly consider it to be well worth the attention of steam consumers, as nothing can be simpler than its application to existing boilers; while if, after a fair trial, it should not be found more economical than coal, that system could at once be resumed. It has been objected that, should liquid fuel burning become general, the price of creosote, or other hydrocarbons, would increase, but taking the recorded results as correct, the increase would have to be very large before it would be more expensive than coal. In steam vessels where the economic value of fuel varies inversely with the weight and bulk, the saving through burning liquid fuel would be very great, especially as stokers and trimmers would be no more required. Another system of burning liquid fuel, viz., that invented by Mr. Dorsett, has also been tried very favourably on board the *Retriever*, the results of which will be found in The Artizan of last month, and which there show a saving of 60 per cent. of the space required for the stowage of coal.

Amongst the various engineering works completed during the past year, we suppose must be included a portion of the Thames Embankment, although only the foot pavement and one of the numerous steamboat piers is at present available. The extraordinary process of filling in the entire width of the embankment, in order that it may be dug out again for the railway passing along it, is we presume the latest style of economical engineering. The public have certainly waited with remarkable patience for some return for their enormous outlay, and it is to be hoped that this year will see the last of such unfortunate bungling. Another immense public work, the main drainage of London has also been to a great extent completed. Here again as is usually the case, when the money necessary for the work is legally extracted from the pockets of the public, considerable extravagance has been shewn. We cannot understand the reason why buildings devoted to the meanest uses, and therefore necessarily placed in out of the way situations should have such elaborate ornamentations heaped upon them; still less the advantage of spending a large amount in chartering steamers, for a whole week, and giving dinners with bad champagne to vestrymen, until they lost all sense of propriety. Another large engineering work—the Midland Railway Extension—has been completed sufficiently to open the line although the magnificent London Terminus is not yet finished. In this instance also though the outlay is far more justifiable than in the two former cases, the pockets of the shareholders could scarcely have been studied when the design for the London Terminus was made; as it is more than probable that they would have preferred a few rows of columns and a less magnificent *coup d'œil*, combined with the comfortable assurance of a good dividend.

London has also been benefited during the past year by the opening of the Millwall Docks—a remarkably fine piece of hydraulic engineering. Although the total area as originally designed has not been excavated, sufficient accommodation for some years to come is provided, the area of the two basins into which it is divided, being about 36½ acres with a depth of 28ft. of water. As a notice of these docks has already appeared in the columns of The Artizan, it need only be mentioned that the whole work reflects great credit upon Mr. John Fowler and Mr. W. Wilson the engineers. Several other docks have been completed during the year, as the Sunderland Docks extension; carried out under the direction of Mr. Thomas Meik, the engineer. The total area is about 28 acres, the cost of the new works being £240,000 extending over a period of three to four years. The new western dock at Hull, of which Mr. Hawkshaw is the engineer, and the Leith docks of which Mr. George Robertson has had the management, have also been virtually completed. Several large dry docks have been completed during the past year, among which may be mentioned the Alfred graving dock at Williamstown, Victoria; another at Martinique for the accomodation of the French navy, and one in the harbour of Rio Janeiro which is cut out of the solid rock. The magnificent iron floating dock for Bermuda of which a detailed description was given in these columns, has been successfully launched. This enormous structure, which reflects great credit upon Mr. Campbell, by whom it was designed and constructed, is we believe the first that has been launched entire—a proceeding that was by many considered hazardous, but which has great advantages upon the score of economy. A floating dock has also been launched on the Tagus for the Portuguese Government. The new harbour at Port Said although unfinished, has been proceeded with so rapidly that but comparatively little more remains to be done. This immense work consists of two piers, enclosing nearly one square mile in extent with an extreme depth of about 27½ft. to be dredged to nearly 30ft.

Several fine bridges have been completed during the past year, among which may be mentioned the Solway viaduct of about a mile in length designed by Mr. James Brunlees. In this viaduct there are 161 spans of 30ft. each, and a swing bridge with two openings of 50ft. span. In consequence of the peculiar nature of the soil, it is supported on cast iron piles driven through the shifting sand into the substratum of gravel

Another beautiful structure—the Runcorn bridge—which has also been opened consists of three spans of 300ft. in the clear, besides having very long approaches. Besides these may be noticed, the suspension bridge across the Niagara just below the Falls, which was designed and constructed by Mr Samuel Keefer, a Canadian engineer. The span of this bridge is the largest that has as yet been built, being 1,268ft., but as it is not intended for heavy traffic it cannot be considered the greatest undertaking of that kind. It appears very questionable whether it can be a lucrative speculation, as it must depend almost entirely upon sight-seers for its traffic, besides which there is already another supension bridge about a mile lower down. A fine bridge has been completed over the Moldau at Prague, upon Mr. R. M. Ordish's rigid suspension principle. The span between the centres of the towers is 492ft., and the total length of the bridge 820ft. The railway bridge at Kuilenburg over the river Lek in Holland is nearly completed. The total length of this bridge is 2,181ft.; the largest span being no less than 492ft. for which are employed immense girders 65½ft. deep, and 515ft. long.

Several important lines of submarine telegraph have been completed; one being the line connecting Cuba with America which, however does not seem at present to fulfil its legitimate object of supplying information that is reliable. The Anglo Mediterranean cable has also been completed, and has been found to possess a remarkably high power of conductivity. A line of telegraph has also been successfully laid from the Tyne to Denmark.

About the progress of shipbuilding in the navy, there is little to record, as, with the exception of the addition of another wall-sided iron clad, and a bastard monitor not yet tried, our fleet remains practically the same. If one half the money wasted upon iron clad forts already crumbling with their own weight, together with the enormous amount thrown away in the civil war between guns and armour plates, had been expended in the construction of first class monitors, our navy would be a credit to the nation. We do not mean by this to assert that all the experiments at Shooburyness and elsewhere have been devoid of instruction, but that after the relative penetrating power of shot at different velocities and of different weights had been established, together with the resisting powers of different thicknesses of iron plates, it was useless extravagance to continue *ad nauseam* to batter similar plates with similar charges year after year. The Dutch Government have during the past year become possessors of two twin screw monitors *De Tyger* and *De Buffel*; these vessels however are scarcely of sufficient tonnage to thoroughly develope this principle.

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## MORTON'S PATENT EJECTOR CONDENSER.

By Messrs. Neilson Bros.

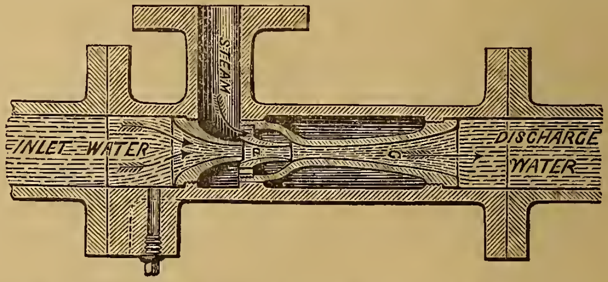
(*Illustrated by Plate* 340).

The subject illustrated in our plate (No. 340) for this month having created considerable interest among the engineers in Scotland, and others who have heard of it, we have, through the kindness of Messrs. Neilson Brothers, been enabled to see the engines at work. From data furnished by them and through the favour of the Institution of Engineers, in Scotland, before whom an important paper by Professor Macquorn Rankine was read in November on the working of the same, we have been enabled to give our readers this notice of what at present appears to be a most important improvement in the economy of the steam engine.

Figs. 1 and 2 (plate 340) are end and front elevations respectively of a pair of small inverted engines of a class suited for screw steam ships, but, in this case, constructed and erected by Messrs. Neilson Brothers, at their works, Hyde Park-street, Glasgow, for the purpose of illustrating the construction, application, and working of the new "ejector condenser," invented by Mr. Alexander Morton, of their firm. Fig. 3 is a complete longitudinal section of the condenser, to a larger scale, in the act of being started by a small starting and regulating steam jet shown open, but which is closed automatically by the vacuum as soon as that is formed and enabled to draw and discharge its own injection water, the valve being used to restore the vacuum when required. This regulator is considered an important part of the practical application of the apparatus, and has been remarked as such by most engineers who have seen it, although other arrangements for a regulating valve might be made, and equally well worked by the action of the vacuum, for the same purpose. The following description of the condenser will explain its action, as we saw it somewhat improved since its first starting, at which the several experiments were taken and reported by Professor Macquorn Rankine in his paper read before the Institution of Engineers in Scotland.

The steam cylinders are 10¼ inches diameter and 18 inches stroke, and have their exhaust pipes connected to the exhaust steam branches shewn on Fig. 3. The exhaust steam after surrounding the injection branch passes on to the parts A and B respectively, where it meets the condensing stream of water, and is condensed and carried away through the pipe C. The starting and regulating valve, Fig. 3, is, as was before observed, remarkably ingenious. It consists of a piston valve for regulating the admission of steam from the boiler or main steam pipe into the steam jet, for the purpose of assisting the current of injection water when the vacuum is not so perfect as to effect this in sufficient quantity, unaided. The chamber behind the piston of the regulating valve is connected by a small pipe with one of the exhaust pipes, as shewn in the section, Fig. 3, so that the vacuum when strong enough shuts the valve against the power of a small helical spring, which is so adjusted as to admit the initial steam the moment the vacuum falls below what is necessary to keep up a sufficient stream of condensing water through the condenser. Thus a jet of fresh steam is instantly supplied when necessary. A small spindle on the piston passes out through the end of the chamber, with a thumb-screw on it, by which the valve may be held open to enable the engines, after standing still, to work with full power and vacuum at any moment, being made self-acting again after the engines are fairly at work. The starting steam jet, conducting the steam to the point of the water nozzle, is formed conoidal at the point, and actuated by a handle to regulate the quantity of injection water allowed to pass through this nozzle. To prevent the injection water condensing the steam in the steam jet, it is surrounded by a hollow casing to prevent the direct metallic contact of the hot and cold surfaces.

Fig. 4.



The wood cut, Fig. 4, is a vertical section of a somewhat similar apparatus constructed for the lifting and forcing of water. This apparatus is placed in the main range or length of pipes through which the water is to be raised, at any distance above the surface of the water within the limits of the atmospheric pressure The height to which the water can be raised in the pipes above it, depends wholly on the velocity of the actuating steam passing through the branch pipe as shewn, and regulated by a valve or cock attached to that branch, so as to act with any desired lateral force through the annular narrow jet round the end of the central nozzle. The water passes up by the inlet water pipe, and is forced or drawn in through the short induction central tube or nozzle by the annular jet of steam, and thence up through the main long curvilineal induction tube, or pipe C; the small induction tube *a*, by preference being cased as shown. The small portion of condensed steam on the outer surface of the tube is forced through the annular slit or jet at its end, into the neck of the induction tube, C, which expands in area in an increasing curve. The lateral branch pipe, made to lead into the main water pipe, close below the nozzle, was only for experimental purposes.

The action of this new condenser, although very different from that of the ordinary condenser and air pump is even more simple. The injection water in rushing into the condenser through the conoidal nozzle, attains a velocity proportional to the vacuum, and this velocity, which the jet of water retains, is found sufficient to enable to it discharge itself through the induction tube C, which is so formed, that its area increases inversely with the velocity of the issuing jet. As the result of many experiments, the inventor has adopted the parabolic curve shown in the engraving. The jet of water in passing through the "ejector condenser" no doubt loses some of its energy by friction in the nozzles, but this loss is made up by the alternate discharges of exhaust steam, from the cylinders in the same direction with, and surrounding the water jet. In manœuvring the engines ahead or astern, the piston starting valve is set open, so that the central steam jet maintains a constant vacuum whether the engines be at work or not; consequently they may be stopped for any period of time, and instantly started at full power when required. As soon as the engines are fairly at work, the starting valve is disengaged, and the vacuum, as before described, shuts off the starting steam jet. The vacuum in the condenser, then becomes the regulator of that valve; and should any person open a grease cock, or otherwise admit air into either cylinder, or into the condenser, to impair the vacuum, that instant the starting valve opens and admits a jet of steam to dispel such air, and keep up the stream of injection water until the vacuum is restored. The point of the central spindle through which the starting steam jet passes, serves the purpose also of an injection valve, whereby more or less water is admitted by its insertion into or withdrawal from the water nozzle by the hand lever shewn in Fig. 3. Since Prof. Rankine made the experiments as given in his paper below, the nozzles have been altered to the form shown in the section Fig. 3 of our engraving and the vacuum has improved 1lb., the average now being 26½in. of mercury instead of 24½in. The quantity of water passing through the condenser has been experimentally reduced, until the discharge water became 140° Fahr., the injection water being 40°, consequently 140—40=100° additional heat was imparted instead of about 40° as in Prof. Rankine's experiments. With this high temperature the vacuum fell nearly 2lbs., the quantity of water being reduced about 60 per cent.

The engines illustrated in our Plate (340), have been frequently run at a speed of 260 revolutions per minute, and, of course, it is evident that a condenser of this description with not a single moving part, cannot be injured by any amount of speed to which the engines may be driven. Several other advantages possessed by the new condenser are so obvious as scarcely to require to be mentioned. Thus, almost the entire weight of the usual description of condenser is saved, besides the greater part of the space so occupied, advantages that it is difficult to over estimate in the case of marine engines; while the cost is said to be only about one-fourth. We hope shortly to be enabled to lay before our readers the result of further experiments upon this remarkable invention which cannot fail to attract considerable attention of engineers throughout the country.

The accompanying indicator diagrams were taken from the lower end of each of the two cylinders, where it will be observed the vacuum is maintained remarkably steadily.

Fig. 5.

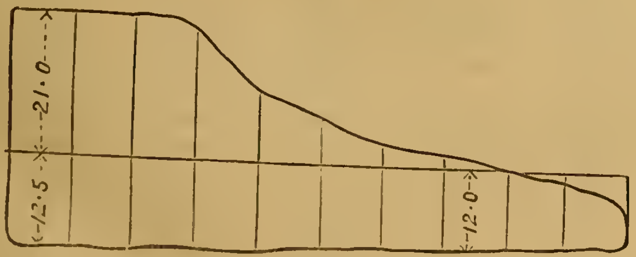
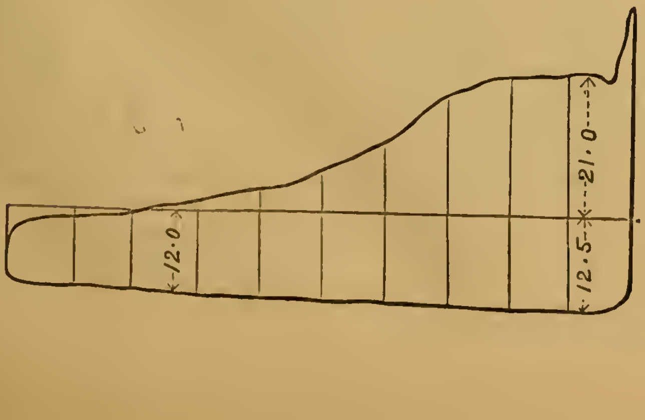


Fig. 6.



## ACCOUNT OF EXPERIMENTS ON MR. ALEXANDER MORTON'S EJECTOR CONDENSER.

By Professor W. J. MACQUORN RANKINE, C.E., LL.D., F.R.S., &c.

The following paper was read before the Inst. Eng. Scot., Nov. 25th, 1868:—The experiments which are the subject of this paper were made at the request of Messrs. Neilson, Brothers, and I have to thank that firm for their permission to make the results public by communicating them to this institution. The ejector-condenser, invented by Mr. Alexander Morton, was applied to a pair of vertical inverted direct-acting steam engines, which exerted collectively a power averaging about 24 indicated h.p. The nominal power of these engines is collectively 7 h.p., if we apply the ordinary rule for low pressure engines, or 15 h.p. if we apply the ordinary rule for high pressure engines. The dimensions of the engines and of the condensing apparatus, and the results of the experiments are given in detail in the annexed table; but as regards the engines, it may be convenient to state here that their two cylinders were of 18 inches stroke, and about 10¼ inches diameter, that they ran at from 93 to 140 revolutions per minute, and that the steam pressure gauge indicated from 30 to 40 lbs. on the square inch above the atmospheric pressure, which at the time was 14.75lbs. on the square inch. It may be remarked that the experiments throw light on other questions besides the efficiency of the new condenser; and in particular that the accurate measurement of the quantity of condensation water, and of its change of temperature affords the means of calculating the total expenditure of steam, and comparing it with the quantity of steam effectively used in doing work, as indicated by the diagrams.

2. The circumstances under which the experiments were made were, to a certain extent, unfavourable to the apparatus; for the pipe which supplied the tank from which the cold water was drawn for condensing the steam was of too small diameter; and the engines had from time to time to be stopped, in order that the tank might be re-filled. It is desirable that a second series of experiments should be made, with a cold water supply pipe sufficient to fill the tank faster than the condensing apparatus empties it. The rate at which the cold water was expended was ascertained by observing on a vertical scale the rate at which the level of the water sank in the tank when the supply pipe was closed; and in this important measurement my own observations were checked by those of Mr. James Brownlee.

2. The principle of the invention may be described as follows:—In every injection condenser the cold water rushes into the vacuum with a velocity of 43 or 44ft. per second or thereabouts. The exhaust steam rushes from the cylinders into the condenser with a velocity which is many times greater than that of the water. In the common condenser those rapid motions of the water and of the steam are completely checked, and their energy is wasted in agitating the fluids in the condenser, and ultimately in producing heat; and hence it becomes necessary to use an air pump in order to extract the water, air, and uncondensed steam from the condenser. The power expended in working a well-proportioned and well-constructed air pump is known by experiment to be equal to that which would overcome a back pressure on the steam piston of from ½ to ¾lb. on each square inch of its area, or on an average, about 0·6lb. on the square inch; and that amount of power is lost through the wasting of the energy with which the jets of water and steam rush into the condenser. In the ejector condenser the motion of those jets meets with no interruption; and its energy is found to be sufficient, without any assistance from pumps, to carry all the water air, and uncondensed steam (if any), completely out of the condenser and into the hot-well, and thus to save the power which would be required to drive an air pump.

4. The principal parts of the condensing apparatus on which my experiments were made may be summarily described as follows:—The cold water passes from the tank to a conoidal nozzle; the area of the orifice of that nozzle is about equal to that of the injection sluice of a common condenser suited for the same engine; that is to say, about 1-250th part of the collective area of pistons. Enveloping the cold water nozzles are a second and a third nozzle of nearly similar figure; these bring the exhaust steam from the two cylinders respectively. The middle nozzle has an orifice a little larger than that of the innermost, or cold water, a nozzle; the outermost nozzle ends in a throat or contracted vein little larger still, beyond which is a gradually widening trumpet shaped mouth-piece, leading to a pipe which ends at the hot-well.

The condensation of the steam takes place in the interval between the orifice of the cold water nozzle and the throat of the outermost nozzle.

5. The completeness and efficiency of the condensation were tested by vacuum-gauges, and by indicator diagrams. By both means of testing the left hand cylinder, which exhausted into the middle nozzle, shewed a rather better vacuum than the right hand cylinder, which exhausted into

the outermost nozzle. The average results of the whole of the experiments were as follows:

| | |
|---|---|
| Mean vacuum shewn by gauges, in inches of mercury, | 24·5 |
| do. do. in lbs. on the square inch, | 12·0 |
| Mean vacuum in cylinders, during return stroke, as shown by the indicator diagrams; lbs. on the square inch, | 10·7 |
| Which, being substracted from the atmospheric pressure at the time, | 14·75 |
| Leaves, as the mean back-pressure in the cylinders during the return stroke, in lbs. on the square inch, | 4·05 |

The back pressure in different experiments ranged between 3 and 4½lbs. on the square inch. These results are at least as good as the average results as to vacuum and back pressure obtained by means of the common condenser; and they show the condensation of the steam and expulsion of the water, air, and vapour, to be at least as complete and efficient.

6. I have estimated the saving of power through the dispensing with an air pump as being equivalent to the doing away with a resistance of 0·6lb. per square inch area of steam-pistons; and I find it to be on an average of the several experiments, just one horse-power; being about 4 per cent. of the mean indicated power of the engines.

I have calculated the energy of the jet of cold water, and I find it to be about three-quarters of a horse-power. This forms the greater part of the energy which is wasted in the common condenser, rendering an air pump necessary.

7. The experiments, then, so far as they have gone, lead to the following conclusions:

*First.* That the action of the ejector-condenser is at least as efficient as that of the common condenser, with its air pump; and

*Secondly.* That by the use of the ejector-condenser the power required to drive the air pump is saved.

8. I have already mentioned one circumstance in the experiments which was disadvantageous to the apparatus, viz.: the insufficient size of the supply pipe of the cold water tank. Another disadvantageous circumstance was, the absence of jacketing and of superheating; for unless one or other of those means be employed, a considerable quantity of steam condenses in the cylinder when first admitted, and re-evaporates during the return stroke; thus at once carrying heat from the boiler to the condenser without performing work, and injuring the efficiency of the condenser.*

I have calculated (as the Tables show) the total quantity of steam expended from its effect on the temperature of the condensation water; and it proves to be on an average about two and a-half times the quantity which performs work in the cylinder, as calculated from the indicator diagrams. When applied to engines that are free from this defect, it may confidently be expected that the new condensing apparatus will give, as regards vacuum and back pressure, results surpassing even the very good performance which has been described.

| SETS OF EXPERIMENTS. | A | B. | C. | D. | E. |
|---|---|---|---|---|---|
| | Right Hand Cylinder. | | Left Hand Cylinder. | | |
| Nos. of diagrams | 1 | { 2·3<br>4·5 | 6 | 7·8 | 9 |
| Revolutions per minute | 130 | 93 | about 140 | 107 | 108 |
| Steam-gauge above atmosphere. Lbs. on the square inch | 34 | from 32 to 38 | ... | 35 | from 40 to 30 |
| Do. do. absolute | 48·75 | from 46·75 to 52·75 | ... | 49·75 | from 54·75 to 44·75 |
| Vacuum-gauges below atmosphere.* Lbs. on the square inch | { 12·03<br>11·54 | 12·4<br>12·1 | ... | 12·3<br>11·8 | ... |
| Do. do. absolute | { 2·72<br>3·21 | 2·35<br>2·65 | ... | 2·45<br>2·95 | ... |
| Mean back pressure | 4·25 | 3·12 | 4·50 | 4·38 | 4·00 |
| Absolute pressure of release | 10·75 | 10·80 | 8·75 | 12·00 | 10·50 |
| Initial absolute pressure | 42·75 | 38·25 | 32·75 | 42·75 | 42·75 |
| Mean effective pressure | 15·25 | 14·83 | 9·85 | 16·78 | 15·90 |
| Mean absolute pressure | 19·50 | 17·95 | 14·35 | 21·16 | 19·90 |
| Temperature of waste water, Fahrenheit | 86°·5 | 80°·5 | ... | 88°·0 | 91°·0 |
| Elevation of temperature above cold water | 39°·5 | 33°·5 | ... | 41°·0 | 44°·0 |
| Heat carried off by water. British units per minute | 28298 | 23999 | ... | 29372 | 31522 |
| Velocity of pistons, feet per minute | 390 | 279 | 420 | 321 | 324 |
| Load of one piston, lbs. | 1220 | 1186·4 | 788 | 1342·4 | 1272 |
| Indicated work of one cylinder, feet lbs. per minute | 475800 | 331006 | 330960 | 430910 | 412128 |
| Do. do. two cylinders | 951600 | 662012 | 661920 | 861820 | 824256 |
| I.H.P. | 28 | 20 | 20 | 26 | 25 |
| Indicated work per minute reduced to equivalent quantity of heat | 1233 | 858 | 858 | 1116 | 1068 |
| Total expenditure of heat, British units per minute | 29531 | 24857 | ... | 30488 | 32590 |
| Efficiency of engines | 0·042 | 0·035 | ... | 0·037 | 0·033 |
| Volume of steam exhausted as shown by indicator in cubic feet per minute | 433 | 310 | 467 | 357 | 360 |
| Volume of 1lb. in cubic feet | 35 | 35 | 43 | 32 | 36 |
| Weight of steam shown by indicator in lbs. per minute | 12·4 | 8·9 | 10·9 | 11·2 | 10·0 |
| Temperature of steam at end of stroke, Fahrenheit | 197° | 197° | 187° | 202° | 196° |
| Total heat per lb. of that steam from temperature of waste water | 1087 | 1093 | ... | 1086 | 1082 |
| Heat of condensation of steam indicated | 13479 | 9728 | ... | 12163 | 10820 |
| Heat carried off by waste water (as before) | 28298 | 23999 | ... | 29372 | 31522 |
| Actual expenditure of steam in lbs. per minute, as calculated from heat of waste water | 26·0 | 22·0 | ... | 27·0 | 29·1 |
| Proportion in which steam actually condensed exceeds indicated steam | 2·10 | 2·47 | ... | 2·41 | 2·91 |
| Work in feet lbs. per minute saved by dispensing with the air pump, estimated as equivalent to 0·6lb. pressure per square inch of steam piston | 37440 | 26784 | 40320 | 30816 | 31104 |
| Do. indicated H.P. | 1·13 | 0·81 | 1·22 | 0·93 | 0·94 |

* First result is for left hand, and second result for right hand engine.

*Table of Experiments made on the 27th October, 1868, on a pair of Engines at the works of Messrs. Neilson Brothers.*

| | |
|---|---|
| Cylinders.—Area of each, allowing for piston rods, about | 80 sq. in. |
| " Stroke | 1.5 foot. |
| Cold Water Nozzle.—Diameter | 0.″9 |
| " " Area | 0.638 sq. in.<br>= 0.00443 sq. ft. |
| Water Tank.—Area 8′ × 3½′ | = 28 sq. ft. |
| " Mean depth of surface below level of nozzle | 5.25 ft. |
| Waste Water Nozzle.—Diameter of throat, $1\frac{5}{16}$ = | 0.″9397 |
| " " Area of throat | 0.690 sq. in.<br>= 0.00479 sq. ft. |
| " " Diameter of mouthpiece, | 3.″0 |
| " " Area of mouthpiece, | 7.07 sq. in.<br>= 0.0491 sq. ft. |
| Cold Water Supply.—Mean rate of flow in cubic feet per minute, | 28′ × 0.41 = 11.48 = 716.4 lbs. |
| " " Do. per second, | 0.1913 = 11.94 lbs. |
| " " Velocity of cold water through nozzle, feet per second, | $\frac{0.1913}{0.00443} = 43.2$ |
| | lbs. per sq. in. |
| " " Head due to that velocity, | 29ft = 12.57 |
| " " Add mean height to which water is lifted | 5.25 = 2.275 |
| " " Total head, | 34.25=14.845 |
| " " Temperature, | 47° Fahrenheit. |
| " " Mean work per minute done in raising and propelling water jet exclusive of friction, | 716.4 × 34.25=24537ft. lbs.<br>=0.744 I. H. P. |

Barometer.—30·05 inches mercury = 14.75lb. on the square inch.

*Abstract of Principal Mean Results.*

| | |
|---|---|
| Mean power saved by dispensing with air-pump, indicated H.P | 1·0 |
| Mean indicated H.P. of engines | 23·8 |
| Mean back-pressure in cylinders, lbs. on square inch | 4·05 |
| Mean vacuum in cylinders do. do. | 10·7 |
| Mean vacuum shown by gauges do. do. | 12·0 |
| Do. do. do. in inches of mercury | 24·5 |
| About two-thirds of the indicated power were due to the vacuum in the cylinders | |
| Temperature of the cold water | 47° F. |
| Mean temperature of waste water | 83½° |
| Mean increase of temperature | 36½° |

Professor Rankine, at the conclusion of his paper, suggested that Mr. Alexander Morton should give some details as to the construction of the apparatus, and the results of some experiments that he had made when he (Professor Rankine) was absent. He might state that the condenser was about 5ft. above the tank from whence the water was drawn; so that the water had to be lifted to that extent. In calculating the pressure due to the velocity plus that lift of 5ft., it was found to be a little greater than the atmospheric pressure of 14·75lbs. upon the inch. He could only account for that by supposing that the impulse of the steam aided the atmospheric pressure in accelerating the jet.

Mr. Morton said he thought Dr. Rankine had very fully explained the matter. The apparatus was before them, and also a sectional model and a full-size drawing, so that he thought that there was little left to be said. He might observe, however, that the only explanation he could give was that the jet of water in rushing into the vacuum had nearly sufficient power to take itself out, and that the impulse of the exhausted steam from the cylinders made up the energy the jet lost in friction. In starting this condenser at first, at times they would shut off the main steam valve while a vacuum was in the cylinders; and in these cases the water was apt to rush into them. He had, therefore, added the regulating spindle and cylinder, which contained merely a piston valve, that opened with a spring as soon as the vacuum fell in the condenser. If any person should accidentally or otherwise open a cock and let in air, the fall of vacuum in the condenser allowed the piston valve to open a jet of steam which kept up the vacuum. The centre regulating spindle could be pushed forward by the handle so as to shut off the injection water. When this condenser was first started there was no cock for shutting off the injection water, and air had to be admitted; but since then he had applied the central spindle which could be used if it were wished to shut off the water, and work the engines high-pressed.

The President asked what the cost of this apparatus would be compared with ordinary air pumps and condensers?

Mr. Morton answered that he thought it would not exceed one-fourth the cost. The boiler which supplied those engines with steam also served hammers, which, together, were rather heavy for the boiler. His experiments had been made while the hammers were at rest. In experiments made since Professor Rankine had been present, the vacuum had risen 1lb. in consequence of the hammers having been stopped. It was often 26in., and he had seen it at 27 and 28in., but it was fair to say that these days when it had reached that figure the barometer was unusually high. When priming water did not enter the cylinder the vacuum rose about 1lb.

Mr. Brown would be glad to know whether the supply pipe for cold water was made larger than the injection pipe, or whether a larger quantity of water was required than with the ordinary jet condenser.

Mr. Morton believed that the quantity of water would be the same. If they raised the water above 30 or 40 degs. they would get a less vacuum. The supply pipe was 2¼in. in diameter.

Professor Rankine said that the cold water nozzle was 13-16th of an in. in diameter; the next nozzle 14-16th of an in.; and the throat of the outermost nozzle was 15-16th of an in.; and that the velocity at the orifice was about 43ft. or 44ft. per second. He thought this condenser would use rather more water than the ordinary jet condenser. In an ordinary injection valve there was some contraction, which diminished the flow of water. The quantity of water that passed through Mr. Morton's condenser was nearly the same whether they were condensing much or little steam.

Mr. Howden said with regard to the water used in condensing, he would suppose that it would be more with Mr. Morton's apparatus than the ordinary condensing jet. He thought the temperature of the water was too low, only 83½ degrees for the vacuum obtained. In a common condensing engine, the discharge water was generally much higher than 83½ degrees—perhaps 120 degrees for such a vacuum—which would almost prove that there would be less injection water used than in the new condenser.

Professor Rankine said he believed there was somewhat more water used than with the ordinary condensing jet; and the consequence was, that the temperature of the water was not raised so much.

Mr. Day said the question then came to be—whether the amount of water used could be reduced? and that he desired to ascertain if in the experiments any attempts had been made to ascertain the minimum of water which could be employed so as to insure the efficient working of the condenser.

Professor Rankine had no doubt that it could be reduced. Mr. Morton had told them that he had introduced a central spindle, by which he could adjust the flow of water to anything he pleased.

Mr. Howden inquired whether there was any reason to believe that the air in the water of condensation would injure the vacuum, as in the common condenser? Looking at this apparatus he would suppose that it would not, and might therefore possibly equal a surface condenser in vacuum, as the air would be driven out and not get into the condensing part.

Professor Rankine believed that the air was carried along with the jet. The tables showed that they did not get results very much better than the common condenser; but then the experiments had been made under disadvantageous circumstances; and it was reasonable to think that when the apparatus got fair play they would get better results—results which might be as good as with surface condensers. Of course, however, this was a question to be decided by experiment.

Mr. Morton might mention that with a little condenser (which he showed), experiments without steam, and with only 2lbs. pressure on the water side, produced a 13lb. vacuum, and by calculation it would be found that this 2lb. pressure rushing into a vacuum would produce, on the vacuum side, that amount by merely rushing through the little condenser. If the trumpet-mouthed discharge tube of the apparatus was cut off, and merely the *vena contracta* nozzle substituted, it would require a pressure of 50lbs. of water, on the water side, to produce 13lbs. vacuum; but by making it of this particular shape, the water pressure could be reduced to 2lbs. and produce the same vacuum, namely 13lbs.

Sir William Thomson expressed the great pleasure with which he had listened to the description of Mr. Morton's invention. The explanations which he had given were admirable in a dynamical point of view. There could be no doubt that there would be very many interesting laboratory applications of this invention. He was much pleased with the last experiment that Mr. Morton had spoken of. The effect of this trumpet-mouth tube in producing a vacuum of 13lbs. was most wonderful. He had seen four months ago in Professor Bunsen's laboratory at Heidelberg an hydraulic apparatus acting to the same effect as this; but probably not of prior date to Mr. Morton's. The general idea of liquids acting in this way was long known, and had had many applications. Bunsen's was for carrying on a process of filtering, which was done by producing a vacuum under a filter, the filter being properly protected. The vacuum he produced simply by water pipes, but he did not know what head of water was necessary; but Bunsen was able to produce a vacuum that corresponded to th temperature of the water used. He had no doubt that the principle was the same as that of the little instrument which Mr. Morton had explained. But whether Bunsen had taken advantage of the trumpet-mouth or not he did not know.

Mr. J. L. K. Jamieson said he had had the pleasure yesterday of looking at the engine referred to in the paper—a pleasure in which he believed many of the members of the Institution had participated. It struck him that Mr. Morton's invention was one of the greatest improvements of the age in the steam-engine. It, indeed, gave the use of an effectual condenser at a cheap cost, But looking at the principle—not merely as an experimental machine—its work was done effectually and well; and he thought that the Institution should give him a very hearty vote of thanks for his invention.

Mr. D. Rowan had not visited Messrs. Neilson Brothers' works, and had not, therefore, seen the condenser working. In so far as regards the consideration of economy, except the first cost, he thought it might be questioned. In the first place, and by the aid of an injector, the work might be done with a less quantity of steam with a common air pump. Then, it would appear that either a greater quantity of injection water was required, or the steam had not the power of heating up the water as in the common condensing engine. In the present case the present feed water would be supplied at 83 degs. or 83½ degs., so that there was a slight loss there. Mr. Morton was entitled to the greatest credit, but as a mere question of economy he thought the air pump might be quite equal to it.

Mr. Morton said it was the exhaust steam that worked this apparatus. He would say that it was considerably below the pressure of the air, and which might only be about 1lb. above the vacuum line. He thought it was all gain, as no direct steam from the boiler was used. As to heating up the water, that was easily got by having too small a condenser in any engine.

Sir William Thompson inquired whether the instrument would continue to act when the vacuum was very imperfect?

Mr. Morton answered that it worked at any point; but with a single engine at Lugar Iron Works he expected that a little from the steam jet would be required all the time; but on experiment it was found that it could be shut off at even 10 strokes per minute. This engine had a stroke of 5ft., and diameter of cylinder 24½in.

Mr. Day said he had heard, but was not prepared to vouch for its authenticity, that when this condenser was started at Lugar Iron Works great difficulty was experienced in working it, so that the proprietor of the works was thinking about dispensing with it. He would like to know whether any improvement had been made upon it, and whether it was now continually and efficaciously at work.

Mr. Morton replied that when the engine was started eight or ten minutes were lost in getting a start. But by stopping the engine and making water pass through the condenser by means of the steam jet, and difficulty had been overcome; and the engine had gone on afterwards night and day, without even complaint as to stoppage, and had never cost the proprietors anything, so that he presumed it continued to work well. He might mention, however, that this engine had never come up to so high a vacuum as others, being only some 10lbs. or 10½lbs. It was an old engine made in Hill-street some 20 years ago, and the water cocks at both ends of the cylinder always showed the presence of great quantities of water, and he had not tried to improve it.

Mr. Brown inquired what height Mr. Morton would expect to discharge the water above the nozzle of the ejector when applied to marine engines; and, as many direct acting screw engines have only one exhaust outlet, whether the ejector would work as well with one as with two exhaust branches?

Mr. Morton said the reason for having two branches in that condenser was to let the steam act without losing much pressure. Engines being often coupled together, one cylinder would then exhaust and would disturb the vacuum of the other. The Corliss engine makers reduce the steam to a very low pressure in the cylinder, and to ascertain whether this low pressure would work the ejector condenser, the first experiments were made. As to the height of raising the water. If the steam were allowed to leave the cylinder at about atmospheric pressure, the water could be forced about 15ft. high. He also found that steam of 5lbs. pressure could lift the water 20ft. high.

Mr. Simons had pleasure on Tuesday in inspecting the apparatus at work in Messrs. Neilson Brothers; it seemed to work admirably. At that time the engine was making 200 revolutions, and he was quite sure that Mr. Morton would show any of the members of the Institution the ejector condenser in operation.

Mr. Downie would like to mention one or two points of interest to engineers in connection with this new ejector-condenser. They all knew the difficulty and expense of applying the air pump to very high speeds, and he had seen the experimental engines at Albert Works making 130 revolutions, and Mr. Simons saw them working at 200; so that this ejector condenser had no limit as to speed of engine apparently. They also knew the difficulty of applying the air pump arrangement to horizontal engines. Without any air pump, and with an apparatus so simple and so very generally applicable, there was no further necessity for having non-condensing engines. Where a supply of water could be had, this apparatus could always be applied with great advantage, and a gain of power which is at present thrown away in all non-condensing engines. He thought Mr. Morton was entitled to their best thanks for bringing the matter before the Institution.

Mr. W. Brock said that the engine was going at 250 revolutions per minute, and the temperature of discharge water 94 degs., when he was inspecting it.

Mr. A. C. Kirk had seen the apparatus, and was extremely pleased with it. It was undoubtedly the best addition that had been made to the steam engine since the days of James Watt. He conceived that to no class of engines would it would it be more immediately valuable than to river steamers, where reduction of weight was of the utmost importance, besides the obvious convenience of it in all land engines, not to speak of other applications which will follow bye-and-bye.

Professor Rankine said that some observations made by Sir William Thompson had recalled to his recollection several instances in which the principle of this gradually widening mouthpiece had been applied to other purposes. One of them was a contrivance applied to drainage, where a depression was made in the channel of the main stream, which ran down at one side of the depression and up at the other; thus making a cavity in the surface of the main stream, which enabled it to receive the water of a branch drain at a lower level than the general level of the main stream. The stream of water coming from the cold well and going to the hot well was analagous to the main drain; and the depression producing a great velocity was analagous to the throat before the trumpet mouthpiece begins to widen. A still more closely analogous case was that of Professor James Thomson's jet-pump. Another analagous case was that of the centrifugal pumps and blowing fans, contrived by Professor James Thomson. The fluid in these machines had a great velocity at the tips of the fan blades, which gradually subsided in the external whirlpool. Blowing fans had also been made with a straight widening outlet instead of the external whirlpool motion of Professor James Thomson; the difference might be likened to that between a French horn and a trumpet. The dynamical principle involved in this widening mouthpiece had had many applications to hydraulic works and centrifugal fans; but the application of it to steam engine condensers was a new and original invention. He agreed with Mr. Kirk, that it was probably the most important improvement that had been made in the steam engine since the time of Watt.

Mr. Downie inquired whether any difficulty was anticipated in the application or use of this apparatus where the jet was required to be very large in diameter, say an ejector condenser for a pair of engines with 80 inch cylinders. Would a single jet proportioned to such have the same effect and produce an equal vacuum; or would it be necessary in that case to put in two or three smaller sized jets.

Professor Rankine saw no reason why engines of increased dimensions should not act as well as the size of the engine brought under notice. However, it was impossible to answer such a question on purely theoretical grounds. Before they know how this instrument would work on a large scale, they must actually make it and see it working; but he saw no reason to apprehend any disadvantage resulting from increased size.

The President asked what was the amount of pressure that was necessary when the new condenser was discharging to a 15ft. height?

Mr. Morton answered, about 6lbs. above the atmospheric line.

Sir William Thompson asked whether it was practically of much advantage to have a head of three or four feet of water?

Mr. Morton said that with that head of water the steam could be wrought down to the finest pressures. He had had that engine working at 28 or 29 inches vacuum by adding a head of water of a few feet to that condenser.

Mr. Lyall said he had been led to understand that Mr. Barclay of Kilmarnock had an apparatus with which he had been experimenting with the same object in view as Mr. Morton. He entertained a doubt like that mentioned by Mr. Downie, that when the apparatus under consideration was applied to large engines the same results might not be easily obtained. He might ask whether a greater number of nozzles than shown on the plan of this ejector had been tried, and with what success? It had also been asked, what height the ejector could throw. He did not think that would be a great objection to its application for marine purposes, as the ejector could be placed at any convenient height in the boat, there being no necessity for placing it in the bottom as is the usual practice with the ordinary condenser. He also thought that this instrument might be of further service by ejecting the water in an opposite direction to that of the vessel and so assist in propelling the latter as Ruthven's propeller did.

Mr. Morton said that as to Mr. Barclay's experiments he knew nothing; but he might mention that since he had brought out his apparatus half-a dozen people had told him they had been thinking of doing the same thing.

## DRAINAGE OF THE THAMES VALLEY.

In pursuance of the Thames Navigation Act of 1866, the Conservators of the River Thames, about the month of April, 1867, gave notice to the local authorities of Oxford, Eton, Windsor, and Abingdon, to sever the connection of their sewerage with the river within 13 months. The duty thrown upon the authorities by this notice amounted, in effect, to an obligation to remove elsewhere the whole of the mass of sewage that had hitherto been carried into the Thames; and the task was not made less difficult by the circumstance of the towns in question being so situate as to render it impossible to rely on gravitation for the distribution of the whole of the sewage over land. The local authorities memorialised the Secretary of State to appoint an engineer to advise them on the course they should adopt with the view of carrying into effect the provisions of the Thames Navigation Act. Accordingly, at the end of June last, Mr. Secretary Hardy directed Lieutenant-Colonel C. B. Ewart, R E., to inquire into the plans for the drainage of the several towns situate in the valley of the Thames with a view to the purification of the river.

Thereupon Colonel Ewart visited the several towns named in his instructions, carefully investigated the existing arrangements for the disposal of the sewage, and examined the country in the immediate vicinity to such an extent as appeared to be requisite. He also visited the following places in order to obtain the benefit of the results of the most recent practical trials—viz., Croydon, where the sewage is distributed by gravitation at Beddington and Norwood; Lodge Farm, near Barking, established for utilization of the sewage of London, which is pumped for distribution on land; Aldershot and Hounslow, where the sewage is utilised on land, in the latter case by pumping with steam power; Canterbury, where the drainage, after being filtered and treated with chymical deodorizing agents, is passed into the river; Broadmoor, where there is a combination of the systems of earth-closets and of utilising sewage by irrigation on land; and Bedford, where the system of utilising sewage on land is extensively carried out.

As a result of these observations it was determined to endeavour to utilise the sewage by distributing the whole of it over the land by means of irrigation. The various plans of precipitation were not considered applicable, being inadequate to purify the sewage to such an extent as required under the Thames Navigation Act.

Colonel Ewart has reported to the Home-office that the separate system is the proper principle of drainage to be adopted in the towns of Oxford, Windsor, Eton, and Abingdon; that a complete system of sewers should be laid out in the above-mentioned towns, to receive all the sewage matter of the towns, and that such sewers should be of such dimensions only as may be sufficient to afford a passage to the sewage matter; that the rainfall should not be allowed to enter into the foul sewers, but should either be stored in tanks for domestic use, or be allowed to flow into its natural channels, care being taken in the event of its running into a river that it is freed from noxious impurities by careful scavenging of the streets, or, if necessary, by passing it into settling beds before allowing it to enter the stream; that, as soon as possible, a complete system of water supply should be provided where it does not already exist, and arrangements should be made for enabling such supply to be used for flushing the sewers; that the water and sewage works of each town should, if possible, be under the control of the same local authority. The colonel points out that, for the purposes of utilisation, the total quantity of land required will depend upon the nature of the subsoil, but as a maximum two thirds of an acre per 100 of the population will suffice, although it would be better to provide one acre per 100, in order to admit of farming the lands subject to the judicious rotation of crops. In conclusion he says,—"I have to state that I am fully alive to the importance of draining the subsoil water in the case of the towns in question, but I am of opinion that drainage of the subsoil water must be conducted on different principles, and in a different manner from the town drainage. In the low lying districts, which form a large proportion of the towns in question, the subsoil, when the river rises, forms in effect an underground lake, in which the water stands with slight variations at the same height as the water in the river. No system of drainage dependent on pumping at outlet can possibly under such circumstances free the subsoil, as the water would flow from the river into the subsoil as quickly as it was drawn from the subsoil by the pumps. It is not within my province to enter into the question of subsoil water, but I make this allusion to it with a view of showing that it has not escaped my observation in recommending the separate system of drainage. The true method of dealing with the subsoil water in the valley of the Thames must depend on an efficient method being devised of bringing the river under control."

In the separate system the sewers are of such size only as is sufficient to carry off the sewage matter, and have no openings into the street, except carefully closed holes for examining the sewers. These sewers, therefore, are free from the objections urged against the joint system in respect to the carriage of sewage, as they are closed throughout their course; they do not afford any exit to injurious vapours, or involve any overflow or any unsafe accumulation of silt or gas. Under this system the sewage delivered at the outfall of the sewage is not over-diluted with rainwater, and the bulk is reduced within manageable compass, and is not liable to vary according to the state of the weather. This bulk, it is true, will be somewhat increased in the towns in question by the necessity which exists for periodically flushing the sewers, as the character of the levels will not admit of the sewage matter descending in all cases by gravitation alone. Granting this, and admitting further that in wet weather no such necessity would exist of flushing sewers under the joint system, Colonel Ewart is, nevertheless, of opinion that even at such times it will prove a cheaper operation to provide a small quantity of water to flush small sewers than to pump over the land an enormous quantity of polluted water, which, in the event of a heavy fall, fills the sewers under the joint system. He admits that the separate system involves in some degree a double system of drains—the one for the rainfall and the other for the sewage matter; but, having regard to the difference in the size of the sewers, to the difference in the cost of providing the plant for pumping, to the current expenses of pumping the sewage matter, and to other considerations, he believes that the separate system, if begun anew, would in the end be, at all events, not more costly than the joint system; and in the case of the towns above-mentioned he has less hesitation in recommending the separate system on the score of expense, as the existing drains may be made use of with little alteration, either for the conveyance of the surface water, or in some cases of the sewage matter, as may be found convenient.

## SMITHFIELD CLUB SHOW.

A very large and complete stock of agricultural machinery was exhibited last month at the Annual Show of the Smithfield Club, at Islington. Though there was undoubtedly much to be admired, not only in the perfection of the workmanship of some well-known firms, but also in the general excellence of the various exhibits, it was rather disheartening to wander all over the entire show without meeting with anything particularly striking in the way of novelty. A very large number of the machines have either been exhibited before, or are so exactly similar to former exhibits by the same makers, that it would be useless to comment upon them again. Many others only differ in being better finished than formerly, this important improvement being chiefly the result of employing tool-work instead of hand-labour for finishing the various parts, and thereby not only ensuring truth in the working parts, but vastly improving the appearance of the machines. The most beautifully finished engine in the entire show, as far as could be seen from the outward appearance, was Messrs. Clayton, Shuttleworth, & Co.'s, 8-horse power horizontal engine—a result evidently obtained by the almost exclusive use of machine tools, for finishing every portion of the engine. The same also might be said of their traction engine, as also the machinery of the Reading Iron Works Company, and many other makers.

Considerable improvement was apparent in the design and manufacture of that handy description of engine—the small vertical stationary. This class of engine has too frequently been made solely with the view to turn out a low-priced article, and great numbers may be seen in various parts of the country, composed of the commonest materials, and "thrown together" in a manner that might well make even a country blacksmith ashamed. This year, however, some really first-rate engines of this class are exhibited; as, for instance, by Messrs. Marshall, Sons, & Co., of Gainsborough, and Messrs. Robey & Co., of Lincoln. The little 2-horse power vertical engine of Messrs. Marshall is a remarkably pretty specimen, having a steam-jacketted cylinder and finished bright—refinements that the usual class of purchasers of this description of engine might think needlessly expensive. Although not absolutely a novelty, the Patent Safety Boiler of Messrs. Howard, of Bedford, has undergone some modifications. The heat is now more equally distributed by a new arrangement of the flues, whereby the flame, after passing under the lower horizontal tubes, is made to return through a species of flue made by means of a cast-iron plate, placed horizontally, at about two-thirds the height of the vertical tubes, after which it passes above this division heating the upper tubes on its way to the chimney. Another improvement consists in lengthening the lower horizontal tubes in the front, so that they project from the setting; the covers upon the ends of each of the tubes being used as mudholes. Messrs. Howard also exhibit a peculiar-looking ploughing engine, with the boiler placed transversely with the body of the machine. It is certainly very compact, but the engines are placed very near to the dirt, and must be very inacessible.

In the galleries there were many things worth notice, but as was mentioned before, but few novelties; the most beautifully-finished piece of machinery being Messrs. J. & H. Gwynne's centrifugal pump, driven direct by a horizontal engine, and intended to circulate the condensing water for a pair of marine engines constructed by Messrs. Stephenson & Co., of Newcastle. One of the few novelties in the show is the model of an apparatus for harvesting in wet weather, invented by W. A. Gibbs, of Gillwell Park. This arrangement consists of a small portable iron house or heating chamber, into which the crop to be dried is placed. A small portable engine, driving a fan, is so arranged as to circulate air, heated by the waste gases of the boiler, through the damp grass or corn, which is thereby speedily dried sufficiently for stacking. A further arrangement in the apparatus consists of a pneumatic elevator, through which the dried material is forced by means of an air blast, to the requisite height for the men employed on the stack. Near to this Messrs. Kitto and Brotherhood exhibited their "Paragon" pump, and also an engine upon the same principle. The idea seems to be very good, and well adapted for small machinery. The construction is very simple, having remarkably few parts, very little friction, and consequently cheap and durable. Another invention near the same spot, is an apparatus designed for the protection of the firebox ends of the tubes of tubular boilers. This consists of a lump of cast-iron, about three inches thick, fitted to the tube plate, and having holes slightly less in diameter than the tubes, exactly opposite each of them. By this means, it is contended, that not only is a new boiler protected, but that leaky tube ends are made to take up, and also that as the cast-iron gets red, it acts as a smoke consumer. We doubt, however, whether this idea is new, though possibly the application may be original. The few inventions described above appeared to be the only absolute novelties in the entire show, though, of course, there were many slight improvements in various well-known machines, such as mowers and reapers, chaff cutters, and various small farm implements. On the whole the show was well worthy of study, if only for exhibiting the steady improvement in the design and workmanship of this most important branch of machinery.

## NEW RAILWAY BILLS.

The notices of intended application to Parliament in the ensuing Session for Railway and Tramway Bills are 78, as compared with 109 for the Session of 1868, 171 for the Session of 1867, 450 for the Session of 1866, and 415 for the Session of 1865. About one-fourth of the notices are for obtaining an extension of time for the purchase of lands and the completion of works, and one-eighth of the whole for the abandonment of numerous railways and branches, including useless and fighting lines, which a few years ago were obtained at great cost.

The notices for the incorporation of new companies are 34, in which it is proposed to incorporate a company to make a railway from the Metropolitan Railway in Clerkenwell to Canonbury-road, Islington; to incorporate a company to make a railway from the London, Chatham, and Dover Railway at Snow-hill to the River Thames at Blackfriars, and thence, by means of a river, wall, or embankment, to Billingsgate and Brewer's-quay, Tower Dock; to incorporate a company to make a railway from Colebrooke-row, Islington, to Union-street, in the City of London, on a 3ft. guage; to incorporate a company to make a railway from Clapham-common to London-bridge; to incorporate a company to make an underground railway to connect the Great Eastern Railway with the North London Railway at Stepney, and also with the East London authorized lines and the Metropolitan Eastern Extension; to incorporate a company to construct an underground railway from near the west-end of Oxford-street to Cheapside; to incorporate a company to make railways from the Elephant and Castle to the Waterloo and Whitehall Railway, the Thames Embankment, and Scotland-yard. Independently of those railways, it is proposed to incorporate a tramway company to lay down street tramways in London on the north side of the Thames; to incorporate another company to lay down street tramways on the south of the Thames, in Surrey; to incorporate a company to lay down tramways 5¼ft. wide along the centre of 17 streets in Pimlico, Peckham, and Greenwich, passing through Lambeth, Camberwell, Kennington, and other places; also to incorporate a company for making tramways, 4ft. 8½in. in width, level with the surface of streets or roads, from Kensington to Hounslow, from Hammersmith to Uxbridge, from Paddington to Harrow and Edgware; from Islington to Barnet; from Newington to Charlton next Woolwich; and from Lambeth to Croydon and to Richmond.

It is proposed to incorporate a company for extending the Great Northern, Edgware, Highgate, and London branch to Harrow. To incorporate a company to make a railway from the London, Chatham, and Dover Railway at Dulwich to Brighton. To incorporate a company to make a railway from the Birkenhead Railway, under the Mersey, to Liverpool, together with two extension railways. To incorporate a company to construct railways to the Mersey, and to work a steam-ferry exclusively across that river. To incorporate a company to construct railways to the Mersey, and to work a steam-ferry exclusively across that river. To incorporate a company to construct a railway from Callingtoe to Calstock, with two branches. To incorporate a company to make a railway from the Whitland station of the South Wales line, up the Taff Valley, to the Crymmych Arms Inn. To incorporate a company to construct a tramway from Chirk to the Cambrian Slate Quarry, in the parish of Llansaintffraid Glyn Geiriog. To incorporate a company to construct a railway from Haddenham to the Great Eastern Railway at Longstanton. To incorporate a company to construct tramways, docks, and warehouses at Holyhead. To incorporate a company (Landowners' Association) to purchase lands and to construct and work railways. To incorporate a company to construct a railway from Richmond, Yorkshire, to the town of Reeth. To incorporate a company to make a railway from Mount-street, Manchester, to Didsbury on a narrow guage. To incorporate a company to make a railway from the East Somerset Railway at Doulting to Mells. To incorporate a company to make a railway from Mayfield to the South Eastern Railway at Ticehurst. To incorporate a company to make a railway from Sandwich to Adisham. To incorporate a company to make railways from Southend to Shoeburyness. To incorporate a company to make a railway from Stoney Stratford to Wolverton. To incorporate other companies to make railways from the Great Eastern Railway at Sutton to Somersham; from the East Lincolnshire railway at Firsby to Wainfleet; from Princes Risborough to Watlington; a railway and pier in the Isle of Wight; a railway from the Thetford and Watton Railway to Swaffham; and from the Brighton Railway to a new station at Worthing. To incorporate a company to facilitate communication between Dover and the Continent by means of powerful steamers and sea works. Notices for the extension of time for the purchase of land and completion of works have been given by 25 companies. Notices of application for the abandonment of authorized lines have been given by the Great Eastern for power to abandon the construction of railways in the parishes of Doddington and East Dereham, the Stratford branch, the Ordnance Factory branch, the Winchmore-hill Railway, a portion of the Highbeach Railway, and the Alexandra Park branch.

The Caledonian Company propose to abandon the railways authorized by the Balerno Branch Act, 1865, the Greenock and Gourock Extensions Act, 1866, the Lancashire and Midlothian Branches Act, 1866, and a portion of the railway authorized by the Branches and Stations Act, 1867, also to apply some of the funds authorized for these to other works. The Caledonian and Glasgow South Western Railway Companies seek power to become joint owners of the Glasgow, Barrhead, and Meilston Direct, the Glasgow Terminal Railway, and the Crofthead and Kilmarnock Railway, with a view to the abandonment of the Kilmarnock Direct Railway. The North British Company seek for power to abandon 12 authorized railways, canals, and other works. The Furness Company propose to abandon the railways authorized by the Windermere and Furness Acts, 1865 and 1866, and to make a new railway to Windermere Lake. The Midland and London and North Western Railway Companies have agreed, on certain terms, for the joint use and working of the Lancaster and Carlisle line (including the Lancaster and Preston Junction and Kendal and Windermere Railway), the Midland Company seek for power to abandon the several railways authorized by the Midland (Settle and Carlisle) Act, 1866, thus rendered unnecessary, only reserving the use of the Citadel station at Carlisle and the lines of railway there. The London and South Western seek for power to abandon the Poole and Bournemouth Junction and a portion of the railway from Bideford to Great Torrington. The Southsea Company to abandon the construction of that railway. The Llynvi and Ogmore desire to abandon all or some of the railways and works authorized by the Llynvi Valley Railway Act, 1866. The Lancashire and Yorkshire wish to abandon an authorized railway in the West Riding of Yorkshire. The London and North Western propose to abandon portions of railways in Lancashire and Cheshire. The Great Eastern, in addition to the abandonment of the branch-lines above mentioned, seek for power to purchase lands and houses at West Ham, Ipswich, Lynn, and Ely; to amend the Finance Act, 1867, and the Additional Powers Act; power to regulate the capital, and alter the present proportions between the stock and loan capital of the company, and to extend the steamboat services to Hamburg and Harburg. The Great Western Company propose to make sidings at Swansea, and a few short junction lines at places in Wales; they require an extension of time for the purchase of land and completion of works, and power to enter into agreements with other companies. The North London Company intend to apply for an extension of time for the completion of works, for power to widen the bridge over York-road, and to make further provision with reference to the running by the company of trains for the labouring classes, and to limit the liability of the company in cases of accident to passengers by such trains. The London, Chatham, and Dover Company propose to widen the bridge over Fleet-lane by 20ft. on the western side; to extend the time for the completion of certain works authorized by the New Lines Act, 1864; power to make agreements with other companies respecting the portion of the Victoria station occupied by the company and Pimlico railway used by the company; to make provision for the amalgamation of the several sections of the company's undertaking, and for determining the conditions of the amalgamation on the basis of a division of net receipts; to make provision for the working and maintenance of the Kent Coast, the Sevenoaks, and the Crystal Palace and South London Junction Railways as part of the system. The Manchester, Sheffield, and Lincolnshire and Midland propose to become joint owners of the authorized Manchester and Stockport Railway, the Marple New Mills and Hayfield Railway, and the Newton and Compstall branches. The London and North Western propose to make some short extension, junction branch, and curve lines at Hulton, Kenyon, Derby, and Nuneaton, and several new roads; and an approach road to the Euston station; power to purchase and hold land and houses in Dublin, Conway, Wigan, Litchurch, Hampstead, St. Pancras, Holyhead, and other places, and to extend the time for the completion of works in the counties of Salop and Flint. The Midland Company propose to make branch and junction railways in the counties of Derby and Leicester, to extend the time for the purchase of land and the completion of works in Bristol, the West and North Ridings of Yorkshire, and the counties of Derby, Somerset, Glocester, Leicester, Nottingham, and other places; power to use the Great Western station and lines at Bristol, and portions of line near Hereford. The Scinde Company propose to amalgamate into one or more companies the separate undertakings of the company. The Severn and Wye Company propose to convert their tramways into railways, either on the broad, narrow, or mixed gauge. The Mid Wales, the Neath and Brecon Junction; the Wrexham, Mold, and Connah's Quay, the Bishop's Castle, the Bristol and North Somerset, and the Denbigh Ruthen and Corwen Railway Companies seek for powers to regulate their capitals, to arrange their affairs, to suspend in some cases for a time legal proceedings, and to sanction deeds of arrangement for the final settlement of creditors' claims.

## THE METROPOLITAN RAILWAY.

A new length of line, forming a section of the New Metropolitan Inner Circle, has just been completed. This section is a continuation of the Metropolitan Railway from Kensington to Westminster Bridge, so that the inner circle is now complete from Moorgate-street to Westminster.

The cost of the construction of this short link of line has been very great, not less than £700,000 a mile, the great bulk of which has of course gone in compensations. The length of new line is nearly three miles, and has six stations—one at Westminster-bridge; one in the Broadway, at St. James's-park; one at Victoria, where it joins the Chatham and Dover line; one at Chelsea, near Sloane-square; one at South Kensington; and one in the Gloucester-road, West Brompton. Of the whole length of line about one-third is tunnel and the rest open cutting. No very special engineering difficulties were met with in the construction of the line except the continued presence of water, as some parts of the works are below low-water mark. The greatest depth below the surface to the rails is not more than 32ft., the quickest curve is 440ft. radius, and the greatest incline 1 in 250ft. Considerable difficulty was experienced during the construction of the line from water, both from the sewers and the surface drainage. On one very wet day in the early summer no less than six sewers burst at once, and gave the pumps enough to do to keep their contents, with the surface drainage, from flooding all that was then built of the line. To this day, and as long as the line is in use, there must always be permanent pumping stations for the mere surface drainage, there being no outlet towards the river without raising it to a higher level. This water difficulty, however, is very ingeniously met by Messrs. Fowler and Johnstone, the engineers of the line. The side walls both of the arched tunnels and open cuttings are made of extra thickness, and, above all, are connected beneath the ground by an inverted arch of concrete nearly three feet thick. This effectually prevents the water rising up through the floor of the line, and equally prevents the surface water from draining off. For this surface drainage, therefore, special provision is made, by means of pipes laid in the centre of the line, and which carry the water on to the pumping stations, where it is raised and sent away into the Thames. Passing under the middle of the Broadway the line is carried, not in a tunnel, but in a broad, lofty, square chamber, with a flat roof, on massive wrought-iron girders. This is a very beautiful piece of work, both in its design and finish. This, as well as the whole of the contract work, has been done by Messrs. Kelk, Lucas, and Waring, and is of the most unexceptionable character from beginning to end. While passing along the Broadway special precautions were taken to guard against any possible vibration affecting the Abbey. The walls on the Abbey side are here made seven bricks thick. Behind this comes the Victoria sewer in a tube of iron, and behind all a bed of peat seven feet thick. The peat checks all vibration, but as the nearest point at which the line passes is more than 90ft. from the Abbey walls, its deadening properties are scarcely required.

After Westminster-bridge the first station is at St. James's park, and leaving this the line continues in an open cutting to Buckingham-row, where it enters a tunnel of about 500 yards in length. Here the water occasioned so much difficulty that engines had to be kept going night and day, pumping at the rate of nearly 4,000 gallons a minute. The tunnel at this point passes but a few feet below the surface of the ground, yet it forms the foundation of the brewery belonging to Elliot, Watney, & Co. above. This building is now carried on a series of girders, but the work had to be done with great care, for the superincumbent weight was immense, and the soil below poor and treacherous. After finishing this portion of the line a fresh difficulty arose with the King's Scholar's-pond sewer, the largest sewer next to that of the Fleet in London. This had to be entirely diverted and reconstructed in an iron tube, 11ft. wide by 14ft. high. So very limited was the space at command that this sewer had to be built over the up and down line in a deeply arched form in order to make room for the funnels of the locomotives. This most difficult of all the tasks on the line has been admirably executed by Mr. T. A. Walker, the resident engineer, who has had charge of the works throughout. A few yards from this point is the station at Victoria, which, like all the others on the line, is open, or rather only closed in with light glass and iron roofs. From this point the line passes on to Sloane-square, a wide and lofty station, but the architectural effect of which is much marred by the Ranelagh sewer being taken in a huge cylinder of cast-iron right across its very centre at the springing of the arches. Continuing westward, the next station is near the site of the Exhibition building of 1862, and to this a new road will be made by a continuation of the Exhibition-road from Kensington. The last station is at Gloucester-road, West Brompton, where the junction is effected with the Metropolitan Extension. The District line then branches to the south and forms a double junction with the West London, by means of which a communication is gained with most of the southern lines at the Clapham Junction.

## ON A NEW SERIES OF CHEMICAL REACTIONS PRODUCED BY LIGHT.

By JOHN TYNDALL, LL.D., F.R.S., &c.

ACTION OF THE ELECTRIC LIGHT.—A glass tube 2·8 feet long and of 2·5 inches diameter, frequently employed in my researches on radiant heat, was supported horizontally. At one end of it was placed an electric lamp, the height and position of both being so arranged that the axis of the glass tube and that of the parallel beam issuing from the lamp were coincident. The tube in the first experiment was closed in plates of rock salt, and subsequently by plates of glass.

As on former occasions, for the sake of distinction, I will call this tube the experimental tube.

The experimental tube was connected with an air-pump, and also with a series of drying and other tubes used for the purification of the air.

A number of test-tubes (I suppose I have used fifty of them in all) were converted into Woulfe's flasks. Each of them was stopped by a cork through which passed two glass tubes: one of these tubes (*a*) ended immediately below the cork, while the other (*b*) descended to the bottom of the flask, being drawn out at its lower end to an orifice about 0·03 of an inch in diameter. It was found necessary to coat the cork carefully with cement.

The little flask thus partially filled with the liquid whose vapour was to be examined; it was then introduced into the path of the purified current of air.

The experimental tube being exhausted, and the cock which cut off the supply of purified air being cautiously turned on, the air entered the flask through the tube *b*, and escaped by the small orifice at the lower end of *b* into the liquid. Through this it bubbled, loading itself with vapour, after which the mixed air and vapour, passing from the flask by the tube *a*, entered the experimental tube, where they were subjected to the action of light.

The power of the electric beam to reveal the existence of anything within the experimental tube, or the impurities of the tube itself, is extraordinary. When the experiment is made in a darkened room, a tube which in ordinary daylight appears absolutely clean is often shown by the present mode of examination to be exceedingly filthy.

The following are some of the results obtained with this arrangement:

NITRATE OF AMYL (boiling point 91° to 96° C).—The vapour of this liquid was in the first instance permitted to enter the experimental tube while the beam from the electric lamp was passing through it. Curious clouds were observed to form near the place of entry, which were afterwards whirled through the tube.

The tube being again exhausted, the mixed air and vapour were allowed to enter it in the dark. The slightly convergent beam of the electric light was then sent through the tube from end to end. For a moment the tube was optically empty—nothing whatever was seen within it; but before a second had elapsed a shower of liquid spherules was precipitated on the beam, thus generating a cloud within the tube. This cloud became denser as the light continued to act, showing at some places a vivid iridescence.

The beam of the electric lamp was now converged so as to form within the tube, between its end and the focus, a cone of rays about 8in. long. The tube was cleansed and again filled in darkness. When the light was sent through it, the precipitation upon the beam was so rapid and intense that the cone, which a moment before was invisible, flashed suddenly forth like a solid luminous spear.

The effect was the same when the air and vapour were allowed to enter the tube in diffuse daylight. The cloud, however, which shone with such extraordinary radiance under the electric beam, was invisible in the ordinary light of the laboratory.

The quantity of mixed air and vapour within the experimental tube could of course be regulated at pleasure. The rapidity of the action diminished with the attenuation of the vapour. When, for example, the mercurial column associated with the experimental tube was depressed only 5in., the action was not nearly so rapid as when the tube was full. In such cases, however, it was exceedingly interesting to observe, after some seconds of waiting, a thin streamer of delicate bluish-white cloud slowly forming along the axis of the tube, and finally swelling so as to fill it.

When dry oxygen was employed to carry in the vapour, the effect was the same as that obtained with the air.

When dry hydrogen was used as a vehicle, the effect was also the same.

The effect, therefore, is not due to any interaction between the vapour of the nitrite and its vehicle.

This was further demonstrated by the deportment of the vapour itself. When it was permitted to enter the experimental tube unmixed with air or any other gas, the effect was substantially the same. Hence the seat of the observed action is the vapour itself.

With reference to the air and the glass of the experimental tube, the beam employed in these experiments was perfectly cold. It had been sifted by passing it through a solution of alum, and through the thick double-convex lens of the lamp. When the unsifted beam of the lamp was employed, the effect was still the same; the obscure calorific rays did not appear to interfere with the result.

I have taken no means to determine strictly the character of the action here described, my object being simply to point out to chemists a method of experiment which reveals a new and beautiful series of reactions; to them I leave the examination of the products of decomposition. The molecule of the nitrate of amyl is shaken asunder by certain specific waves of the electric beam, forming nitric oxide and other products, of which the nitrate of amyl is probably one. The brown fumes of nitrous acid were seen to mingle with the cloud within the experimental tube.

The nitrate of amyl, being less volatile than the nitrite, could not maintain itself in the condition of vapour, but would be precipitated in liquid spherules along the track of the beam.

In the anterior portions of the tubes a sifting action of the vapour occurs, which diminishes the chemical action in the posterior portions. In some experiments the precipitated cloud only extended halfway down the tube. When, under these circumstances, the lamp was shifted so as to send the beam through the other end of the tube, precipitation occurred there also.

Action of Sunlight.—The solar light also affects the decomposition of the nitrite-of-amyl vapour. On the 10th of October I partially darkened a small room at the Royal Institution, into which the sun shone, permitting the light to enter through an open portion of the window shutter. In the track of the beam was placed a large plano-convex lens, which formed a fine convergent cone in the dust of the room behind it. The experimental tube was filled in the laboratory, covered with a black cloth, and carried into the partially darkened room. On thrusting one end of the tube into the cone of rays behind the lens, precipitation within the cone was copious and immediate. The vapour at the distant end of the tube was in part shielded by that in front, and was also more feebly acted on through the divergence of the rays. On reversing the tube, a second and similar cone was precipitated.

Physical Considerations.—I sought to determine the particular portion of the white beam which produced the foregoing effects. When, previous to entering the experimental tube, the beam was caused to pass through a red glass, the effect was greatly weakened, but not extinguished. This was also the case with various samples of yellow glass. A blue glass being introduced, before the removal of the yellow or the red, on taking the latter away, augmented precipitation occurred along the track of the blue beam. Hence, in this case, the more refrangible rays are the most chemically active.

The colour of the liquid nitrate of amyl indicates that this must be the case; it is a feeble but distinct yellow; in other words, the yellow portion of the beam is most freely transmitted. It is not, however, the transmitted portion of any beam which produces chemical action, but the absorbed portion. Blue, as the complementary colour to yellow, is here absorbed, and hence the more energetic action of the blue rays. This reasoning, however, assumes that the same rays are absorbed by the liquid and its vapour.

A solution of the yellow chromate of potash, the colour of which may be made almost, if not altogether, identical with that of the liquid nitrite of amyl, was found far more effective in stopping the chemical rays than either the red or yellow glass. But of all substances the nitrite itself is most potent in arresting the rays which act upon its vapours. A layer one-eighth of an inch in thickness, which scarcely perceptibly affected the luminous intensity, sufficed to absorb the entire chemical energy of the concentrated beam of the electric light.

The close relation subsisting between a liquid and its vapour, as regards their action upon radiant heat, has been already amply demonstrated.*

As regards the nitrite of amyl, this relation is more specific than in the cases hitherto adduced; for here the special constituent of the beam which provokes the decomposition of the vapour is shown to be arrested by the liquid.

A question of extreme importance in molecular physics here arises:—What is the real mechanism of this absorption, and where is its seat? †

I figure, as others do, a molecule as a group of atoms, held together by their mutual forces, but still capable of motion among themselves. The vapour of the nitrate of amyl is to be regarded as an assemblage of such molecules. The question now before us is this:—In the act of absorption, is it the molecules that are effective, or is it their constituent atoms? Is the *vis viva* of the intercepted waves transferred to the molecule as a whole, or to its constituent parts.

The molecule, as a whole, can only vibrate in virtue of the forces exerted between it and its neighbouring molecules. The intensity of these forces, and consequently the rate of vibration, would, in this case, be a function of the distance between the molecules. Now the identical absorption of the liquid and of the vaporous nitrate of amyl indicates an identical vibrating period on the part of liquid and vapour, and this, to my mind, amounts to an experimental demonstration that the absorption occurs in the main within the molecule. For it can hardly be supposed, if the absorption were the act of the molecule as a whole, that it could continue to affect waves of the same period after the substance had passed from the vaporous to the liquid state.

In point of fact, the decomposition of the nitrite of amyl is itself to some extent an illustration of this internal molecular absorption; for were the absorption the act of the molecule as a whole, the relative motions of its constituent atoms would remain unchanged, and there would be no mechanical cause for their separation. It is probably the synchronism of the vibrations of one portion of the molecule with the incident waves which enables the amplitude of those vibrations to augment until the chain which binds the parts of the molecule together is snapped asunder.

The liquid nitrate of amyl is probably also decomposed by light; but the reaction, if it exists, is incomparably less rapid and distinct than that of the vapour. Nitrate of amyl has been subjected to the concentrated solar rays until it boiled, and it has been permitted to continue boiling for a considerable time, without any distinctly apparent change occurring in the liquid.

I anticipate wide, if not entire, generality for the fact that a liquid and its vapour absorb the same rays. A cell of liquid chlorine now preparing for me will, I imagine, deprive light more effectually of its power of causing chlorine and hydrogen to combine than any other filter of the luminous rays. The rays which give chlorine its colour have nothing to do with this combination, those that are absorbed by the chlorine being the really effective rays. A highly sensitive bulb, containing chlorine and hydrogen in the exact proportions necessary for the formation of hydrochloric acid was placed at one end of the experimental tube, the beam of the electric lamp being sent through it from the other. The bulb did not explode when the tube was filled with chlorine, while the explosion was violent and immediate when the tube was filled with air. I anticipate for liquid chlorine an action similar to, but still more the energetic, than that exhibited by the gas. If this should prove to be the case, it will favour the view that chlorine itself is molecular and not monatomic. Other cases of this kind I hope, at no distant day, to bring before the Royal Society.

Production of Sky-blue by the Decomposition of Nitrite of Amyl.—When the quantity of nitrite vapour is considerable, and the light intense, the chemical action is exceedingly rapid, the particles precipitated being so large as to whiten the luminous beam. Not so, however, when a well-mixed and highly-attenuated vapour fills the experimental tube. The effect now to be described was obtained in the greatest perfection when the vapour of nitrate was derived from a residue of the moisture of its liquid, which had been accidentally introduced into the passage through which the dry air flowed into the experimental tube.

In this case the electric beam traversed the tube for several seconds before any action was visible. Decomposition then visibly commenced, and advanced slowly. The particles first precipitated were too small to be distinguished by an eye-glass; and, when the light was very strong, the cloud appeared of a milky blue. When, on the contrary, the intensity was moderate, the blue was pure and deep. In Brucke's important experiments on the blue of the sky and the morning and evening red, pure mastic is dissolved in alcohol, and then dropped into water well stirred. When the proportion of mastic to alcohol is correct, the resin is precipitated so finely as to elude the highest microscopic power. By reflected light, such a medium appears bluish, by transmitted light yellowish, which latter colour, by augmenting the quantity of the precipitate, can be caused to pass into orange or red.

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* Phil. Trans., 1864.

† My attention was very forcibly directed to this subject some years ago by a conversation with my excellent friend Professor Clausius.

But the development of colour in the attenuated nitrite-of-amyl vapour, though admitting of the same explanation, is, doubtless, more similar to what takes place in our atmosphere. The blue, moreover, is purer and more sky-like than that obtained from Brucke's turbid medium. There could scarcely be a more impressive illustration of Newton's mode of regarding the generation of the colour of the firmament than that here exhibited; for never, even in the skies of the Alps, have I seen a richer or a purer blue than that attainable by a suitable disposition of the light falling upon the precipitated vapour. May not the aqueous vapour of our atmosphere act in a similar manner? and may we not fairly refer to liquid particles of infinitesimal size the hues observed by Principal Forbes over the safety-valve of a locomotive, and so skilfully connected by him with the colours of the sky?

In exhausting the tube containing the mixed air and nitrite-of-amyl vapour, it was difficult to avoid explosions under the pistons of the air pump similar to those which I have already described as occurring with the vapours of bisulphide of carbon and other substances. Though the quantity of vapour present in these cases must have been infinitesimal its explosion was sufficient to destroy the valves of the pump.

Iodide of Allyl (boiling point 101° C).—Among the liquids hitherto subjected to the concentrated electric light, iodide of allyl, in point of rapidity and intensity of action, comes next to the nitrite of amyl. With the iodide of allyl I have employed both oxygen and hydrogen, as well as air, as a vehicle, and found the effect in all cases substantially the same. The cloud column here was exquisitely beautiful, but its forms were different from those of the nitrite of amyl. The whole column revolved round the axis of the decomposing beam; it was nipped at certain places like an hour-glass, and round the two bells of the glass delicate cloud-filaments twisted themselves in spirals. It also folded itself into convolutions resembling those of shells. In certain conditions of the atmosphere in the Alps I have often observed clouds of a special pearly lustre; when hydrogen was made the vehicle of the iodide-of-allyl vapour, a similar lustre was most exquisitely shown. With a suitable disposition of the light, the purple hue of iodine vapour came out very strongly in the tube.

The remark already made, as to the bearing of the decomposition of nitrite of amyl by light on the question of molecular absorption, applies here also; for were the absorption the work of the molecule as a whole, the iodine would not be dislodged from the allyl with which it is combined The non-synchronism of iodine with the waves of obscure heat is illustrated by its marvellous transparency to such heat. May not its synchronism with the waves of light in the present instance be the cause of its divorce from the allyl? Further experiments on this point are in preparation.

Iodide of Isopropyl.—The action of light upon the vapour of this liquid is at first more languid than upon the iodide of allyl; indeed many beautiful reactions may be overlooked in consequence of this langour at the commencement. After some minutes' exposure, however, clouds begin to form, which grow in density and in beauty as the light continues to act. In every experiment hitherto made with this substance the column of cloud which filled the experimental tube was divided into two distinct parts near the middle of the tube. In one experiment, a globe of cloud formed at the centre, from which, right and left, issued an axis which united the globe with the two adjacent cylinders. Both globe and cylinders were animated by a common motion of rotation. As the action continued, paroxysms of motion were manifested; the various parts of the cloud would rush through each other with sudden violence. During these motions beautiful and grotesque cloud-forms were developed. At some places the nebulous mass would become ribbed so as to resemble the graining of wood; a longitudinal motion would at time generate in it a series of curved transverse bands, the retarding influence of the sides of the tube causing an appearance resembling, on a small scale, the dirt-bands of the Mer de Glace. In the anterior portion of the tube those sudden commotions were most intense; here buds of cloud would sprout forth, and grow in a few seconds into perfect flower-like forms. The most curious appearance that I noticed was that of a cloud resembling a tongue was rapidly discharged. The cloud of iodide of isopropyl had a character of its own, and differed materially from all others that I had seen. A gorgeous mauve colour was developed in the last twelve inches in the tube; the vapour of iodine was present, and it may have been the sky-blue produced by the precipitated particles which, mingling with the purple of the iodine, produced this splendid mauve. As in all other cases adduced, the effects were proved to be due to the light; they never occurred in darkness.

I should like to guard myself against saying more than the facts warrant regarding the chemical effect produced by light in the following three substances; but the physical appearances are so exceedingly singular that I do not hesitate to describe it.

Hydrobromic Acid.—The aqueous solution of this acid was placed in a small Woulfe's flask, and carried into the experimental tube by a current of air.

The tube being filled with the mixture of acid, aqueous vapour, and air, the beam was sent through it, the lens at the same time being so placed as to produce a cone of very intense light. Two minutes elapsed before anything was visible; but at the end of this time a faint bluish cloud appeared to hang itself on the most concentrated portion of the beam.

Soon afterwards a second cloud was formed 5in. further down the experimental tube. Both clouds were united by a slender cord of cloud of the same bluish tint as themselves.

As the action of the light continued, the first cloud gradually resolved into a series of parallel discs of exquisite delicacy; the discs rotated round an axis perpendicular to their surfaces, and finally they blended together to produce a screw surface with an inclined generatrix. This surface gradually changed into a filmy funnel, from the end of which the "cord" extended to the cloud in advance. This also underwent modification. It resolved itself into a series of strata resembling those of the electric discharge. After a little time, and through changes which it was difficult to follow, both clouds presented the appearance of a series of concentric funnels set one with the other, the interior ones being seen through the spectral walls of the outer ones; those of the distant cloud resembled claret glasses in shape. As many as six funnels were thus concentrically set together, the two series being united by the delicate cord of cloud already referred to. Other cords and slender tubes were afterwards formed, and they coiled themselves in spirals around and along the funnels.

Rendering the light along the connecting cord more intense, it diminished in thickness and became whiter; this was a consequence of the enlargement of its particles. The cord finally disappeared, while the funnels melted into two ghost-like films, shaped like parasols. The films were barely visible, being of an exceedingly delicate blue tint; they seemed woven of blue air. To compare them with cobweb or with gauze would be to liken them to something infinitely grosser than themselves.

In a second trial the result was very much the same. A cloud which soon assumed the parasol shape was formed in front, and five inches lower down another cloud was formed, in which the funnels already referred to were considerably sharpened. It was connected as before by a filament with the the cloud in front, and it ended in a spear-point which extended 12in. further down the tube.

After many changes, the film in front assumed the shape of a bell, to the convex surface of which a hollow cylinder about two inches long attached itself. After some time this cylinder broke away from the bell and formed itself into an iridescent ring, which, without apparent connection with anything else, rotated on its axis in the middle of the tube. The inner diameter of this ring was nearly an inch in length, and its outer diameter nearly an inch and a half.

The whole cloud composed of these heterogeneous parts was animated throughout by a motion of rotation. The rapidity of the rotation could be augmented by intensifying the beam. The disks, funnels, strata, and convolutions of the cloud exhibited at times diffraction colours, which changed colour with every motion of the observer's eye.

Moisture appeared to be favourable to the production of these appearances; and it hence becomes a question how far they were really produced by the light: hydrobromic acid, even from its solution, fumes when it comes into contact with the aqueous vapour of the air; its residence in water does not appear to satisfy its appetite for the liquid. The same effect, as everybody knows, is observed in the solution of hydrochloric acid. Might not, then, those wonderfully-shaped clouds be produced by an action of this kind, the presence of the light being an unnecessary accident?

The hydrobromic acid was permitted to enter the experimental tube and remain in diffuse daylight for fine minutes. On darkening the room and sending the electric beam through it, the tube was optically empty. Two minutes' action of the light caused the clouds to appear, and they afterwards went through the same variety of changes as before.

No matter how long the hydrobromic acid was allowed to remain in the tube, no action occurred until the luminous beam was brought into play. The tube filled with the mixture of air, aqueous vapour, and hydrobromic acid was permitted to remain for fifteen minutes in the dark. On sending the beam through the tube, it was found optically empty; but two minutes' action of the light developed the clouds as before.

Permitting the beam to pass through a layer of water before entering the experimental tube, no diminution of its chemical agency was observed. Permitting it to pass through a solution of hydrobromic acid, of the same thickness, the chemical action of the beam was wholly destroyed. This shows that the vibrations of the dissolved acid are synchronous with those of the gaseous acid, and is a new proof that the constituent atoms of the molecule, and not the molecule itself, is the seat of the absorption.

Hydrochloric Acid.—The aqueous solution of this acid was employed and treated like the solution of hydrobromic acid. I intend to invoke the aid of an artistic friend in an effort to reproduce the effects observed during the decomposition, if such it be, of hydrochloric acid by light. But artistic skill must, I fear, fail to convey a notion of them. The cloud was of slow growth, requiring fifteen or twenty minutes for its full development. It was then divided into four or five sections, every adjacent two of which were united by a slender axial cord. Each of these sections possessed an exceedingly complex and ornate structure, exhibiting ribs, spears, funnels, leaves, involved scrolls, and iridescent fleurs-de-lis. Still the structure of the cloud from beginning to end was perfectly symmetrical; it was a cloud of revolution, its corresponding points being at equal distances from the axis of the beam. There are many points of resemblance between the clouds of hydrochloric and hydrobromic acid, and both are perfectly distinct from anything obtainable from the substances previously mentioned; in fact, every liquid appears to have its own special cloud, varying only within narrow limits from a normal type. The formation of the cloud depends rather upon its own inherent forces than upon the environment. It is true that, by warming or chilling the experimental tube at certain points, extraordinary flexures and whirlwinds may be produced; but with a perfectly constant condition of tube, specific differences of cloud-structure are revealed, the peculiarity of each substance stamping itself apparently upon the precipitated vapour derived from its decomposition.

When the beam before entering the experimental tube was sent through a layer of the aqueous acid, thirteen minutes' exposure produced no action. A layer of water being substituted for the layer of acid, one minute's exposure sufficed to set up the decomposition.

Hydriodic Acid.—The aqueous solution of this acid was also employed. On first subjecting it to the action of light no visible effect was produced; but subsequent trials developed a very extraordinary one. A family resemblance pervades the nebulæ of hydriodic, hydrobromic, and hydrochloric acids. In all three cases, for example, the action commenced by the formation of two small clouds united by a cord; it was very slow, and the growth of the cloud in density and beauty very gradual. The most vivid green end crimson that I have yet observed were exhibited by this substance in the earlier stages of the action. The development of the cloud was like that of an organism, from a more or less formless mass at the commencement, to a structure of marvellous complexity. I have seen nothing so astonishing as the effect obtained, on the 28th of October, with hydriodic acid. The cloud extended for about 18 inches along the tube, and gradually shifted its position from the end nearest the lamp to the most distant end. The portion quitted by the cloud proper was filled by an amorphous haze, the decomposition which was progressing lower down being here apparently complete. A spectral cone turned its apex towards the distant end of the tube, and from its circular base filmy drapery seemed to fall. Placed on the base of the cone was an exquisite vase, from the interior of which sprung another vase of similar shape; over the edges of these vases fell the faintest clouds, resembling spectral sheets of liquid. From the centre of the upper vase a straight cord of cloud passed for some distance along the axis of the experimental tube, and at each side of this cord two involved and highly iridescent vortices were generated. The frontal portion of the cloud, which the cord penetrated, assumed in succession the forms of roses, tulips, and sunflowers. It also passed through the appearance of a series of beautifully shaped bottles placed one within the other. Once it presented the shape of a fish, with eyes, gills, and feelers. The light was suspended for several minutes, and the tube and its cloud permitted to remain undisturbed in darkness. On re-igniting the lamp, the cloud was seen apparently motionless within the tube; much of its colour had gone, but its beauty of form was unimpaired. Many of its parts were calculated to remind one of Gassiot's discharges; but in complexity, and, indeed, in beauty, the discharges would not bear comparision with these arrangements of cloud. A friend to whom I showed the cloud likened it to one of those jelly-like marine organisms which a film barely capable of reflecting the light renders visible. Indeed no other comparison is so suitable; and not only did the perfect symmetry of the exterior suggest this idea, but the exquisite casing and folding of film within film suggested the internal economy of a highly complex organism. The twoness of the animal form was displayed throughout, and no coil, disc, or speck existed on one side of the axis of the tube that had not its exact counterpart at an equal distance on the other. I looked in wonder at this extraordinary production for nearly two hours.

The precise conditions necessary to render the production of the effects observed with dydrobromic, hydrochloric, and hydriodic acids a certainty have not yet been determined. Air, moreover, is the only vehicle which has been employed here. I hazard no opinion as to the chemical nature of these reactions. The dry acids, moreover, I have not yet examined.

## ON THE ECONOMY OF FUEL CONSIDERED IN ITS RELATIONS TO STEAM ENGINES.

By Francis Campin, C.E.

No sooner were the thermomotive engines applied to the purposes of commerce than the attention of practical engineers and scientific men generally was directed towards determining the conditions which regulate the economy of fuel.

Commencing with the construction of Newcomen's atmospheric engine, we find that from that period down to the time of Wicksteed gradual but steady advances have been made in the improvement of furnaces, boilers, and thermomotive engines of all descriptions. In Smeaton's time the number of foot-pounds of duty done by the consumption of 112 lbs. of Newcastle coal was raised from four and a half millions to nine millions; but the "Wickstood" pumping-engine at the East London Waterworks, at Old Ford, Bow, attained a nett duty of 100 millions of foot-pounds per 112 lbs. of Newcastle coal consumed in the furnaces.

Thus we find that some of the highest intellects have been applied to the study of the subject on which we are now treating, and superficially it might appear that but little remains to be said. However, a careful consideration of the actual economy now attained will show that such is not the case, as we shall subsequently indicate.

Our present object is not to advance any new theories or arguments, nor even to support peculiar opinions, but rather to review the means at our disposal for ascertaining the actual economic or commercial value of fuels submitted for trial, and especially to point out some of the various sources of error generally present at experimental trials.

First, we will make a few observations as to the quality of fuels. Theoretically the evaporative value of fuel may be determined from a formula, in which the known quantities are obtained from a chemical analysis of the fuel under consideration, but in practice the results obtained from such calculations are but of very little use, so much depending upon the character of the furnace or combustion chamber in which the fuel is consumed. The fact that peculiar modifications or extensions are required in special cases does, in great measure, account for the comparatively slight patronage enjoyed by patent fuels, although many samples have been satisfactorily proved to be superior in many respects to coal or coke. Thus no general rule can be laid down as to what fuel is best, because in practice we are surrounded by contingent circumstances which undermine the postulates on which our theories are based, and nullify the results of our most careful calculations. Hence every case with which we have to deal becomes special, and requires consideration, with but a very limited regard for the results of other apparently similar investigations, and with especial observation on all and every the minutest particulars concerning the one machine, the efficiency of which we are called upon to ascertain.

Let us suppose that we desire to ascertain the efficiency of an ordinary stationary rotative engine and that of its boiler. A special experiment should be first made to determine the quality of the fuel proposed to be employed, so that the average evaporation in pounds of water per pound of fuel may be known; then, if we do not obtain such evaporation of water in the boiler, there is evidently some deficiency either in the arrangement of the furnace or that of the heating surface in the boiler.

A perfect furnace should admit just sufficient air to effect complete combustion of the fuel, but not excess enough to cool the gases and cause loss of heat; for that heat absorbed by the air not used for combustion, and by it carried away at the uptake or chimney, can only be regarded as useless waste. The desiderata, then, to satisfy the question of furnace efficiency, are these:—

The admission of just sufficient air to cause perfect combustion;
Vivid and rapid combustion;
The greatest absorption of heat from the igneous gases.

The first is to be obtained by the employment of suitable dampers; the second will result as a matter of course if the draught be sufficient, and the furnacce properly attended, so that the fuel shall not become caked together in excessively large masses. The third point, that of absorption of heat, depends upon the arrangement of flue tubes.

Experiments were made a few years back with a view to obtain perfect combustion with a minimum quantity of air, in which the fuel was burnt under pressure, the fire-box was fitted with a loaded outlet valve, and the air required forced into the furnace; under these conditions very satisfactory results were attained by the patentees, a great saving—viz., about 30 to 40 per cent.—of fuel said to be effected. There were, of course, some difficulties to be eliminated, but there were none of a very serious character. The patentees, however, have, as far as we can ascertain, let their invention pass into disuetude, but not on account of any disadvantages pertaining to it.

It seems to us that in order to obtian the desiderata mentioned above, the drought should be produced rather by the ascending tendency of a short column of intensely heated gases, issuing from the furnace, than from the buoyancy of a lofty column of less highly heated air in the shaft or chimney. The intensely heated air would produce great propelling force on the gases in front of it already cooled by contact with the absorbing water surfaces, and, issuing from the furnace chamber, would yield up its heat to the water the more readily in proportion to the greater temperature imparted to it, ultimately contracting as it cools; thus, with a judicious system of heating surfaces, vivid combustion might be obtained with a comparatively slow draught, the igneous gases passing away exhausted of their caloric.

The description of furnace used in any particular case will, of course, very materially influence the economy of the fuel, and should always be designed with regard to the nature of the combustible to be used. some kinds scarcely burning except under the most powerful draughts, and others requiring mild or diffused currents of air to produce the most satisfactory effects.

The most effective heating surface is, of course, that which lies in a horizontal position, but if all the heating surface is so placed, the draught must be produced by a high chimney or by a blast engine. We consider that the latter is preferable, and for the same reasons as advanced above in reference to the propulsion of draughts by a short column of highly heated gases close to the furnace.

There has been much discussion as to the value of superheating steam. We may, however, here observe that we do not regard the system favourably, but incline to think that, with boilers of a more perfect design than those ordinarily used, the whole of the available heat may be absorbed with greater advantage by the water than by the steam; for the expansion of dry steam due to the excess of a given amount of heat is not nearly so great in proportion or capable of producing results so considerable as would ensue from the evaporation of a quantity of water by the same access of heat. This point may be determined theoretically with ease; but so long as there is waste heat than can be taken up in superheaters, although not admitting of absorption by the water, it is, of course, advisable to use such heat by the only means at our disposal.

All these considerations apply to the case we have supposed to be submitted to us practically only so far as alterations may be applied to the steam generator or its appurtenances; but a just study of them will enable us the more readily to appreciate the qualities of a boiler upon cursory examination; hence they may be regarded as worthy of attention.

Having determined the efficiency of the boiler, that is to say, having ascertained its evaporation of water per lb. of fuel, the next step to be taken is to measure the amount of condensation in the steam pipes and passages. This process is by no means easy of execution, and it requires very careful and accurate calculation, giving even then results not nearly so reliable practically as might be desired.

The amount of water lost by condensation will be equal to the difference in quantity of the water which is evaporated and disappears from the boiler and that which is used as steam in the engine. It is, of course, assumed that there is no leakage in the boiler or in any of the attachments, and, this being very seldom the case, we cannot be sure that the loss found by calculation in entirely due by condensation in the steam pipes and passages.

The amount of water consumed as steam in the cylinder must be calculated from indicator cards, which afford all requisite information, giving the point of cut-off and the pressure at that point, from which data, the capacity of the cylinder being known, the quantity used may be calculated; this, deducted from the quantity of water evaporated from the boiler, gives as a remainder the amount of the losses above enumerated.

From the steam used in the cylinders must be deducted that lost in clearance, to leave the amount actually doing work, if we wish to be very exact in determining the friction of the engine, which is done in the following manner:—By means of a dynamometer of ordinary construction, the actual amount of work given off the main shaft of the engine is determined, and this deducted from the amount of work done by the steam in the cylinder, as shown by the indicator diagram, leaves as a remainder the amount of work done by the steam in the cylinder, as shown by the indicator diagram, leaves as a remainder the amount of work absorbed in friction, in the bearings, pistons, packings, valve faces, &c. By pursuing this system we obtain, not only the efficiency of the entire machine, but an analysis of the efficiency of each part of the machine, and of the various losses from bad draught, condensation, &c. The value of such a system of testing efficiency of steam machinery chiefly consists in its proving a guide to the future; thus, for instance, if we have two sets of engines and boilers by different makers, and find them equal in point of economy of fuel, if only the work done by the engine and the weight of fuel consumed in the boiler has in each case been determined, we should, if requiring a third set of engines and boilers, order them on one or the other plan indifferently; but if the two first cases were analysed, as above indicated, it might be found that in one case the increased economy was due to the construction of the boiler, in the other to that of the engine. This ascertained, of course in the case of a third set being required, the designs would comprise the best boiler adapted to the best engine, when the result would be a still further improvement in point of economy.

In determining the economy of fuel in Cornish pumping engines there is the advantage, as far as calculation goes, that the work of the engine consists in lifting a definite weight of constant value; but it must be remembered that this class of engine, having no fly-wheel, the length of stroke varies, and may not be the same for two consecutive strokes. Hence it becomes necessary in exact experiments to register to scale the length of every stroke during such experiments. By taking such precautions we have found that the calculated friction of the engine is in value very nearly equal to the quantity found by experiment.

It is difficult at the present time to make much out of the reports of trials of efficiency, as in comparatively few cases can we obtain anything like correct or complete information as to the circumstances under which such trials are made, and it generally occurs that all experiments give results far more favourable than are ever obtained in ordinary working; and this is not difficult to account for. Thus, while an experiment is being conducted, the fireman and engineer are tolerably sure to be more attentive and diligent than at ordinary times; to this alone may be attributed very considerable improvements in working.

In proof of this we may mention a circumstance which some years back came under our consideration, and which certainly illustrates in a very striking manner the mistakes into which inventors fall.

A scheme was promoted for the consumption of smoke in boiler furnaces which consisted chiefly in forcing air into the fire at a short distance behind the firebridge. As the experiment was of a temporary nature, a pair of smith's bellows was fitted to force the air into the flue according to the specification of the inventor. A saving of fuel amounting to 10 per cent. was effected; but, at the termination of the experiment, the bellows were found to be burst and useless; and upon inquiry it was discovered that they had been in that condition from the first, the forge from which they were taken having been thrown out of work on that account.

Scarcely two engineers will give the same opinion as to the actual value of different descriptions of fuel, and there is not as much faith put in the trials of fuels by committees and scientific bodies as we might wish them to deserve. Hence we are left very much in the dark, and we have to fall back upon chemical analysis, which we have already observed is not such a reliable test for practical purposes as is requisite; but for our own purposes, with a properly designed engine and boiler, we would prefer good coal to any fuel which has yet come under our notice.

## THE LONDON ASSOCIATION OF FOREMAN ENGINEERS.

The usual monthly meeting took place on Saturday, the 5th ult. It was very numerously attended, and the chair was occupied by Mr. J. Newton, of the Royal Mint, president. The first business of the evening consisted in the election, as honorary members, of Messrs. A. McGillivray and A. Anderson, and this was followed by a discussion as to the time, place, and general arrangements for celebrating the seventeenth anniversary of the formation of the institution. Finally it was determined that this should take the form of a banquet, to be conducted on a scale similar to that of February last, and which had given great satisfaction. The time named for the celebration was the middle of February next. Mr. James Irvine, of Messrs. Simpson's Engine-works, Pimlico, then proceeded to read a paper "On Rock Boring Machinery."

After some general remarks as to the desirability of having an unbroken succession of monthly papers for the ensuing year, the author addressed himself to his subject. He described the various appliances which had been contrived in time past for penetrating rocks by mechanical means, and showed wherein they had generally failed. By this course Mr. Irvine enabled his audience to institute comparisons, and comprehend more clearly his explanation of a rock-boring engine, now at work in Cornwall, and which was, he said, in every way successful. The latter was known as Doering's patent. It is scarcely necessary here to follow the author of the paper in his preliminary statements, and we shall only, therefore, reproduce some of the main points of the concluding portion of the paper of Saturday. "Mr. Doering's rock-boring engine," said Mr. Irvine, "consists of a gun-metal cylinder bored out to a diameter of $2\frac{3}{4}$in., or an area of about 6in., and fitted with a steel piston. It is worked by compressed air at a pressure of from 25 lb. to 30 lb. per square inch, thus 30 × 6 = 180 lb., which is the pressure or blow administered to the drill at every stroke of the engine, the speed of the latter being 300 strokes per minute. The piston and rod are forged in one piece, the rod being hollow and pierced with a number of holes, at proper intervals, and for a purpose to be explained hereafter. To the outer end of the piston rod the boring drill is attached and fastened by an ordinary key, with a moveable nut, which permits of readjustments when the constant hammering loosens the drill. The packing throughout the engine consists of metallic rings, which answers well, and minimise friction. The piston differs but slightly from that well known as Ramsbottom's, and is worked to and fro by compressed air admitted to the cylinder by aid of a circular slide valve of peculiar construction, and which is a model of simplicity. The valve itself gains alternate motion by the action of compressed air. (The movement was made clear by diagrams). In the centre of the piston rod is a square hole into which is fitted a ¾in. steel bar, on the end of which is a ratchet wheel with twenty-four teeth. When the main piston has passed a certain point in its travel the air rushes through a hole from the large into the small cylinder and drives its piston forward. This acts upon the pawl and ratchet, and causes the latter to move to the extent of one tooth; the effect is to give the drill a partial turn at each stroke and an entire revolution at the end of twenty-four strokes. The air from the small cylinder escapes through the hollow piston rod into the atmosphere.

The method of "feeding" the drill forward into the rock is ingenious yet simple, and accommodates itself self-actingly to the hardness, or otherwise of the rock to be bored. [This was sactisfactorily demonstrated by diagrams supplied, and can hardly be made intelligible without them]. The stand for supporting the apparatus and allowing it to move laterally or vertically, is portable and easy of attachment by pressure of air at any spot, on the principle of the sucker, or the pneumatic hat peg. Ball and socket joints on the arm of the stand allow a universal movement of the apparatus it supports . . . . the air pumps for compressing the air are three in number, and worked by a three-throw crank, driven by a small steam-engine. The pumps are immersed in water to keep them cool.

Many more details were furnished by the author of the paper, as well as particulars of the work effected by engines of the kind in various mines of Cornwall, but it is not possible for us at present to give them place. The great merits of the contrivance appears to us to be its adaptability for its purpose, its simplicity, economy of action, and automatic character.

A practical discussion followed Mr. Irvine's paper, and this was shared in by Messrs. Edmonds, Keyte, Dewar, Walker, Stokoe, Gibbon, Bunt, the Chairman, and others. The sitting terminated with a vote of thanks to the author.

## SOCIETY OF ENGINEERS.

### THE ACCUMULATOR COTTON PRESS.

By Ewin Matheson.

The trade in cotton, under its many different aspects, forms so large an item in the commercial activity of this country, and is so largely increasing, that every incident and process in production and manufacture possesses a corresponding interest for all concerned.

Although for very many years the importation of cotton and its manufacture into fabrics have been among the greatest industries of Great Britain, it is only more recently that the production of the raw material has engaged any considerable share of British capital and enterprise. The immense importance now, however, of the cultivation of cotton in India and the colonies, and through them to the mother country, is, of course, manifest to all. The growth of cotton in India, Egypt, and elsewhere was formerly so small in comparison with that of the Southern States of America, that it needed the artificial stimulus given to it by the American war, and consequent closing of the cotton ports, to produce a commercial success.

This success has survived its immediate cause, and Indian, Egyptian, and colonial cotton now take a permanent place in the British market. The rapid increase and present enormous extent of this trade may be seen from the fact that in the first six months of the year 1866, 119,000 tons of cotton were imported into the United Kingdom from India, and 30,476 tons from Egypt. The shipment from India for 1868 shows an apparent decrease; but this is owing to the fact that a great quantity of cotton that was formerly sent from Bombay to the United Kingdom for re-shipment to the Continent is now sent direct to France and elsewhere. The Indian cotton exports are really increasing annually. From Egypt, the amount exported to this country in the first six months of the present year wass 7,000 tons more than in 1866, and the present crop promises to allow a still further increase.

There are several disadvantages with which India has to struggle. Assuming that the first cost of tillage and agricultural labour is the same, there than remains the immense difference between India and America in distance and time of transit from the port of departure to the port of arrival. From New Orleans to Liverpool the distance is 6,000 miles, and twenty days' voyage for a steamer. From Bombay to Liverpool (round the Cape) the distance is 12,000 miles, and takes 129 days. Thus in the race India is heavily handicapped. The carriage of the cotton costs more, and the time expended in the voyage from India to England renders unproductive for a long time the money represented by the cotton cotton bales; and four months' interest is of no small consequence in these days of close competition. It will be seen, therefore, that the cotton producer in India must study every item of expense, and that every detail of cost and incidental outlay is of greater importance to him than to his more highly favoured rival in the United States. If the Suez Canal were but open, the voyage by the Cape would be avoided; but opinions differ as to the ultimate success of that scheme, and the route certainly does not exist at present. The Isthmus Railway was intended for the same purpose, but the cost of transhipment and land carriage is so great that there is practically little advantage in bringing cotton that way, and till lately it was only silk and other expensive goods that were brought overland. Recently a considerable amount of cotton has been sent across the Isthmus, but until better arrangements are made for its transport by the Suez Railway, only an inappreciable quantity of cotton will come by that route.

It will be seen, therefore, there is every inducement to save, if possible, in the cost of freight. Now, the freight payable on bales of cotton is calculated by the ton of measurement, and not by the ton of weight; and therefore the more cotton that can be compressed into a bale of given size the lower the rate becomes per lb., and the greater becomes the amount of profit.

The foregoing preface shows the important service that can be rendered by powerful baling presses; and while this is especially the case with India and Australia, it is true also for Egypt and other less distant places, where the experses or irrigation and tillage may form a large proportion of the total cost. Moreover, it is desirable that no time should be lost at the port of shipment, but that the packing process should be performed speedily.

Considering that for many years America had almost the monopoly of the cotton supply, it might be expected that as the trade grew up in India and Egypt, all the designs for the requisite apparatus could be at once copied from America. As is well known, invention does not sleep in the United States, and it might be presumed that for any production in which the people are engaged, the best appliances would soon be discovered and made use of in that country. It is not surprising, therefore, to hear that for all the details of pressing cotton a great variety of plans have been tried. As has been shown, however, there is no such urgent inducement to the merchants in America to compress so much cotton into a bale for the short voyage to England. The cotton itself also differs from that produced in India. It is, as a rule, cleaner and more elastic, and would require much more power to compress the same number of pounds into a cubic foot than is necessary with Indian cotton.

While the cotton culture in India was in its infancy, the quantity produced was too small to create a demand for any special apparatus. Baling machines were sent out from England, but they were of a very primitive kind. Screw presses, something like those used for making cheese, were contrived. The next step was to work the vertical screws by gearing and a winch. Then, as the cotton trade grew in importance, there was devised a number of inventions and contrivances, some by engineers, and others by the cotton growers, whose ingenuity was stimulated by necessity, the mother of all invention. Levers, screws, and wedges were tried alone and in combination. The use of hydraulic pressure naturally suggested itself for trial, but it was not very successful; no very great power was obtained, and the process by pumping was slow.

Gradually improvements were made in the lever presses, and these were generally preferred. Some of them may be mentioned. A Mr. McComb took great pains to make a good baling machine, and patented several of his improvements. His cotton was forced up by two compound levers, drawn together by a chain worked by hand or steam (see Fig. 1).

Mason's press (Fig. 3) had somewhat the same principle of levers, but was worked in a different way. A horizontal engine drove two machines, the crank-shaft running right and left from the engine. By gearing, a shaft parallel to the crank-shaft was driven at a reduced speed, and by means of right and left hand screws on these shafts two powerful levers were drawn together and forced upwards against the follower of the cotton box. Both these presses are still in favour, and are used in considerable numbers; yet, however well they may be made, it is obvious that there must be severe strains upon the points through which the power is transmitted—strain, it must be remembered, which are excessively heavy at each occurrence of the final pressure to a bale. There are in Bombay companies formed specially for pressing cotton, and the leading merchants also have pressing factories of their own, and the different kinds of presses are held to be best by their respective owners. A machine known as Hodgart's cotton press embodies a very ingenious combination of hydraulic and lever powers. Fig. 2 shows the method by which the pressure is put upon the cotton by the force of the hydraulic ram on the levers. The process by pumping being in ordinary presses slow, it was here endeavoured to reduce the quantity of water necessary to be pumped by having a ram of small area, and by multiplying the power so gained by the levers. This press, at its usual rate of speed, will pack ten bales per hour, and it is possible to do fourteen; but this is too severe labour for the men. At the time of the Abyssian expedition hay was packed for the troops at the rate of fifteen bales per hour; but this was an exceptional and extraordinary speed that could not well be repeated. It is considered, in Bombay, good work to pack eight to ten bales per hour with the presses generally used. All the machines that have been here described are compound in their action, and are subject to severe and varying strains. The Bombay Press Company uses Nasmyth's press, which is one of the best that has yet been invented.

No diagram is necessary to show its action, which is extremely simple. The pressure is effected by three hydraulic rams placed side by side. At the beginning of the stroke, while the cotton is in a pliable state, the power is applied by one cylinder only. Towards the end of the stroke the other two rams are also set in motion, the two cylinders having been previously filled with water, so as to save time in pumping when the power is supplied to them.

Mr. George Ashcroft, having given this subject much attention, invented and patented a machine in which he obtained the power of hydraulic pressure combined with rapidity. The first and easy pressure on the cotton was rapidly effected by a steam piston, only the final and severe pressure being given by a hydraulic ram. This press worked satisfactorily, and would probably have been pushed to success by the inventor, had he not thought of something better. If the first evolving of a simple but important mechanical principle be a great thing, the extension of it to processes in which it has not been adopted before is of almost equal practical importance. Mr. Ashcroft determined to apply the accumulator to a cotton press, and has most successfully done so.

Before describing this machine, the writer would remark that he had very much wished to obtain accurate information of the machines used in America, and felt that no discussion would be complete that ignored the practice of the greatest cotton-growing country in the world. He had failed in procuring drawings from the United States, but has had a long letter from an engineer in New York, who has given this subject his special attention for many years, and who sends home some very interesting particulars. As might be expected, there are in America a vast number of inventions for all processes connected with cotton. In the various cotton states there are differences of custom as to the size of the bales, and so in Texas, North and South Carolina, Georgia, and Florida, there are different kinds of baling machines used. Levers and screws, hydraulic and screw presses, have been combined in many different ways, and with varying success. Wood is more used in America than in England in the construction of machines, and machines so made would probably not find favour elsewhere. Very likely English machines would be condemned there. As one of the incidents arising out of the war, when the Southern ports were shut out from the rest of the States, the blockade runners took over English made presses, and, among others, some of McComb's, but they found no purchasers. Every other detail of cotton packing is studied by inventors in the States, and the correspondent before referred to says that there are some fifty different patents even for modes of fastening the baling hoops. In the London Patent Office the writer has seen more than a dozen specifications on the same subject. Is would be interesting if the printing of the present paper were to result in the supplying definite information from America on the whole subject.

The Accumulator Cotton Press is the invention of Mr. George Ashcroft, who designed the machine to fulfil the two main requisites of great power and of speed. While in theory there is no limit to the force that can be exerted by hydraulic pressure, in practice the difficulties commence at a certain point. So far as these machines have been used hitherto, a maximum pressure of two tons to the square inch has been employed; but even with this enormous pressure, it is necessary to have a considerable area of ram to obtain the required total, and to get this with one cylinder involves practical difficulties, well known to engineers. It at all times requires great care and skill to cast cylinders capable of taking high hydraulic pressure, and the risk increases very rapidly with the diameter with the cylinder. While with a small diameter, a moderate thickness of metal will successfully endure enormous pressure, cylinders of large diameter must be made of great strength to resist fracture. But as beyond a certain thickness cast-iron becomes spongy and porous, such casting would be liable to unsoundness and the water would ooze through to the surface. Moreover the castings would be inconveniently heavy and difficult to transport. In the present invention the required area is obtained by placing three cylinders with 8in. rams side by side, and these giving a total area of 150in., a force of 300 tons is produced by the pressure before named. If necessary this pressure could be increased, as, in fact, a much higher degree had been obtained with hydraulic presses.

The box in which the cotton is pressed is in plan of the dimensions usual for a marketable bale, and in height sufficient to hold enough loose cotton to give a bale of the required thickness when pressed. The box is made entirely of wrought iron, strongly framed, and the upper part of it, where the ultimate pressure is received, is of considerable thickness. This part of the box is planed all over, so as to present a true and smooth surface to the cotton. The doors are made so that three of the four sides can open. One of the special points in this invention, for which a separate patent has been secured, is seen in the revolving boxes, the advantages of which will be apparent when the operation of the machine is described. The "accumulator" is of the well-known simple kind, consisting of a cylinder and ram, the latter supporting a box which, as the ram ascends and descends, moves up and down in guides. This box can be made either of wood or iron, and can be filled with any heavy substance, such as stone, iron, or gravel.

There are a set of three hydraulic pumps of equal size, driven by a pair of horizontal engines. From these pumps there are communicating pipes to the accumulator and press rams, and to the small differential cylinder.

The mode of working is as follows:—The house consists of a ground floor and two floors above. Upon the ground floor are fixed the steam-engine, the pumps, and the press and accumulator cylinder; but the latter might, if necessary or convenient, be placed a hundred yards away. The framework of the press reaches through the floor to the top of the chamber above. In the uppermost chamber the loose cotton is stored, and when the baling takes place at the port of shipment the ginned cotton generally arrives in loosely packed bales. On the centre floor are the handles for working the valves, and here is posted the engineer who has control of the machine.

During the whole time of pressing and baling the cotton the engines and pumps are at work. The dead load in the accumulator box is forced up with a pressure on the ram of less than one ton to the inch, the exact weight in the box determining the precise degree of pressure which has to be exerted upon the ram. This accumulated power having been obtained, the apparatus is ready for work.

The men upon the top floor having placed the bagging in the box, and filled it with loose cotton, which they trample down, the men below push the revolving boxes round, so that the cotton-filled box is over the rams. The boxes revolve upon the strong vertical column, the weight being taken on balls, which rest upon the collar, the bearing surfaces above being turned and bored to fit.

A portion of the floor revolves with the boxes: The hooping irons having been placed in recesses at the top of the press, the engineer opens the valve which admits the high pressure water to the rams. At once the accumulator box descends, and the three rams of the press ascend, forcing the loose bottom of the box upon the cotton. But as the accumulator box descends, the pumps being still at work, in some measure restore the height of the water column, and the accumulator ram gently ascends and descends as the water is thus withdrawn and restored. When the cotton is compressed upwards as tightly as the rams can force it, the engineer shuts the valve which admits the water from the accumulator and the pumps, and opens one which admits the water from the differential cylinder. By means of rams of different diameters the pressure given by the pumps is in this cylinder multiplied. The superior power thus produced forces up the three rams, and with them the cotton, the last few inches of the stroke to the ultimate point desired. One of the doors of the box is then opened, the hoops are fastened, and then the other doors being opened, the water in the cylinder is let to waste, and the rams descend. The elastic cotton at once expands into the small distance allowed by the hoops, and with but slight assistance from the workman the bale tumbles from the box and falls down a shoot to the floor below. Meanwhile the other box having been filled with cotton, it is pushed round into its place over the rams, and is in its turn subjected to the pressure of the water, and so the process is repeated without intermission.

The merits claimed by the inventor for his machine are as follows:—It being acknowledged that of all mechanical appliances hydraulic pressure exerts the greatest force, full advantage is taken of the fact by having a large area of rams and a high pressure. More than 30 lb. of cotton per cubic foot can be compressed and held within the hoops for shipment, and as after pressing, the elastic cotton expands, and slightly stretches the hoops, a larger quantity than 30 lb. has to be squeezed at the final moment of pressing to obtain the above result. The simplicity and smoothness of the process obviates the excessive wear and tear which is unavoidable in machines where the pressure is obtained by levers or screws. The friction on the packing leathers is extremely small. Great uncertainty existed until recently on this point, and all makers of hydraulic presses differed from each other on the subject. Professor Rankine gave 10 per cent. of the total load as the amount wasted by the friction of the leathers, but the whole question has been most successfully investigated by Mr. Hick, of Bolton, who by his experiments, which are recorded in his admirable little treatise published last year, proves that the friction of the leathers on an 8 in. ram is about 1-200th part of the total load, the decimal varying from ·003 to ·005 according as the leathers are more or less worn, and well or sparingly lubricated.

*Speediness of Action.*—The principal of the accumulator is well known, and for working cranes, opening dock gates, and many other purposes, has been in operation some time. It is probable that sooner or later some one would have supplied it to cotton baling presses, but at any rate Mr. Ashcroft has *done* it, and he only. Instead of the power, whether it be that of steam, water, men, or cattle, having to be applied as is necessary in other presses, with concentrated energy during the short time of the actual compression of the cotton, in the present case during the whole time of filling the boxes, changing them, and hooping the bales, the pumps are quietly at work forcing up the accumulator box, which at the proper moment gives forth all its power and does all that is required in a few seconds. The revolving boxes are an ingenious part of the machine, and by their arrangement obviously save much time. Twenty-five or more bales can be packed and hooped per hour.

*Endurance.*—The power being direct acting, there are few parts that are liable to need repair, and the occasional renewal of the packing-leathers entails but a small expense.

In Alexandria the accumulator press is in full operation, and at Bombay also it is exciting much interest among the cotton merchants, some of whom are now in treaty with a view to its adoption there.

In conclusion, the writer would remark that the importance of the cotton trade having been the cause of so many attempts to make good presses, the same cause is no less a stimulus now. The cotton trade is increasing so rapidly in India, Egypt, and elsewhere, that the best machines will undoubtedly have to be be adopted by all those who wish to keep pace with the age. The railways that are being opened remove one great hindrance to the cotton grower. Hitherto, the cotton has been packed loosely in the growing districts by the natives, and has had to be repacked at the port, the merchant not daring to send to England bales that might be filled with dirty cotton, or with stones to increase the weight. The inland carriage of the cotton is very expensive, and like the freight by ship, is calculated by the bulk occupied by the cotton. It has been almost impossible to take up country the heavy machinery necessary for pressing bales in a marketable condition, but as the railway system is developed, it is probable that in the centre of the growing districts proper presses will be established. Mr. Ashcroft is now giving his attention to a village press, the particulars of which he may possibly send home to the society.

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## ON THE APPLICATION OF STEAM TO THE CULTIVATION OF THE SOIL.

By BALDWIN LATHAM.

### *Introduction.*

Man, when leaving the haunts of savage life, and advancing toward the goal of civilisation, is seen cultivating the soil with the rudest implements and by the power of his own exertions; but, as he advances onward in the race of civilisation, he presses into his service the inferior animals to relieve him from the drudgery of his situation and to perfect his work; as he further advances the higher animals are rendered subservient to his will and employed to aid and assist him in his undertakings. Now, just as we see in the dawn of civilisation the savage depending on his own labour for the cultivation of the soil, and, as the light of knowledge has shone upon him and ripened his faculties, so do we see the forces that he originally applied to the soil, increased; and it may fairly be presumed, from past experience, that, as knowledge is still more perfected, the aids to cultivation will be still more increased, and ere long the all-powerful agency of steam will be universally taken into the service of the agriculturist and applied to the cultivation of the soil, when it will be found as useful and serviceable in this capacity as it has been already found in preparing the crops for the use of both man and beast. Considerable progress has been made within the last few years in the means and appliances whereby the giant power of steam has been successfully applied to the cultivation of the soil; but the number of machines at present in operation, compared with the very large number of agriculturists, is comparatively small. Now, it must be evident to the attentive observer that the increase of our population, the competition of free trade, and the gradual rise in the wages of the country, must lead the agriculturist to adopt such measures as will enable him to keep pace with the times; and he will therefore have to adopt the all-powerful agency of steam in order to get the greatest results with the utmost certainty and at the least cost. We are told by chemists that fields of untold agricultural wealth lie in the hitherto almost unmanageable clay soil of our country. In steam we have the magic wand that will convert the hidden treasures of our clay fields into food for the people. The day is not far distant when steam will be universally employed, for political economists inform us that "the machinery of a country will naturally correspond with its wants and the history and the state of its people;" and never was greater want felt than at the present time for the improvement of the agricultural interests of the country; and as landlords and farmers get more enlightened, steam will be more and more employed, until its adoption will become universal.

A lesson may be learnt by the agriculturist from the rapid development of manufactures of our country by reason of the impulse given to them by steam, which, when learnt, will lead him to substitute, for the present tedious process of cultivation by the aid of flesh and blood, the iron sinews of the never-tiring steam engine. There are obstacles existing at the present time that interfere materially with the development of steam for the cultivation of the soil, but which, sooner or later, must be removed; for we see that, unless agriculture can be stimulated and assisted, ultimately the result of the abstraction of labour from the soil, which is rapidly on the increase (the labour being diverted into channels mose profitable to the labourer), the result to the agricultural interests of the country must be disastrous. The introduction of steam to the cultivation of the soil will tend to stop the diversion of labour from the land, and also to educate and elevate the social position of the labourer.

We have the recorded testimony of some hundreds of the most advanced and enterprising farmers of our country, all testifying to the great advantage of using steam power for the cultivation of the soil; and the results already obtained are conclusive evidence to warrant the agriculturist in adopting steam cultivation with manifest economy and advantage.

### *Advantages of Steam Culture.*

The most valuable period of the year to the farmer for the cultivation of the soil is the six weeks in September and October, and all the autumn, cultivation, to be executed to the greatest advantage, should, as a rule, be performed in this limited space of time. Now, it is found by long experience, and especially in bad seasons, that it is impossible, with horse labour, for all the land to be cultivated in the proper seasons; and, even if the number of horses kept by the farmer is sufficient to perform the work at the proper time, the gain is purchased at the expense of keeping a larger number of horses throughout the year than on the average will be found requisite and remunerative. Therefore we find, as a rule, that, in order to keep down the expenses of the farm, a very large quantity of land is tilled out of the proper season. But this is not the only drawback to horse labour, for it is well known and admitted by the intelligent agriculturist that the fertility of the soil, in a great measure, depends upon its mechanical condition, and on the perfect comminution to which the staple is reduced. Now, whenever horses are employed to plough a field, that field is trodden in parallel lines—sometimes by as many as six horses; and as each horse, when drawing, will probably exercise a direct pressure of one ton, and as such treading takes place in the fresh ploughed furrow, it naturally follows that the subsoil of a field of moderately stiff soil, when the field is ploughed by horses, is completely puddled; and the freshcut furrow slice is turned upon the puddled and obdurate subsoil, rendered so by repeated surface ploughing and the ramming and consolidation due to the mechanical action of the feet of horses. The enormous extent to which this ramming takes place may be ascertained from the fact that it is calculated that, with a team of four horses, and a 12in. furrrow, upwards of 300,000 footprints are made on every acre ploughed. Nor is the ploughing the end of the evil, for, by every subsequent operation of harrowing, drilling, or other mode of treatment, the thin film of earth turned by the plough is injured by being again trodden down by the feet of horses. This puddling of the subsoil, interfering as it does with the drainage, and preventing the due admission of the atmosphere, renders the soil cold and unfruitful; and the repeated treading of the surface not unfrequently effectually replants any weeds that may have been turned beneath the furrow slice, thus showing how far from perfection is the present system of horse cultivation as generally adopted by the farmer. The application of horse power, so far as the power is concerned, has been shown to be prejudicial to the perfect cultivation of the soil; but it may also be shown that in ploughing with horses the implements used more or less tend to add injury to the injury created by horse labour; for we find that nearly the whole weight of the ordinary plough sets on the subsoil, and produces, when at work, a hard glaze, that renders the subsoil still more impervious.

How different are the results when steam is adopted, and the modern implements as used in steam cultivation! We find the implements are balanced, so that the weight rests on wheels, and as these wheels progress over the soil they are followed by a grubbing tine which effectually erases the impression made by the implement.

That it is an absolute necessity that the farmer should perform his work at the proper season, will be better understood when it is considered that he has to carry on his labour in conjunction with the ordinary working of nature. It is the farmer's province to prepare for nature, for to atmospheric influences the fertility of the soil is in a great measure due, and unless the farmer can prepare in time, the great advantage derivable from atmospheric agencies will be lost. The crude processes in agriculture are performed by the farmer, but it is nature that perfects the work. Time and opportunity are everything to a farmer, especially in a climate so uncertain as ours; and the possession of a machine that abridges the time and space by its own great power and untiring energy will often make all the difference to a farmer between success and failure, certainty and uncertainty. By the power of steam the farmer is able to break up the impervious pan that has been formed in the course of years by horse culture; he has also the power of tilling his land to a greater depth, the benefit of which connot be overlooked; for by this deep tillage the staple is increased, which is equivalent to an increased surface area, because the productive capacity of the soil is increased.

Where steam power is applied to the cultivation of the soil, owing to the great power that is brought to bear on a limited surface, the tilth is reduced to a perfect mechanical condition; and, in consequence of the total absence of those destructive agencies that are actively at work where the soil is cultivated by horse power, the soil and subsoil retain there porosity, thus enabling the atmospheric agencies to exercise their full and unobstructed power upon the staple of the soil. Mr. Moscrop, in his Essay on Steam Cultivation, for which the Royal Agricultural Society awarded him their prize, says that with steam cultivation "a deeper staple, a better tilth, more perfect comminution of the soil is obtained than could possibly be got by the use of horses: but on strong soils, as surely as cultivation by steam is more economical than horses—as surely as its use increases porosity and promotes percolation—as surely as it better comminutes and deepens at will the staple of the soil—so surely does the final result tend to the production of better crops, and consequently to greater profit." It is a well-established fact that steam cultivation greatly facilitates the work of drainage, and that on farms where, before the steam plough was introduced, the rainfall used to drain off the surface in such a way as to create injury to the fields, or destroy the neighbouring roads by washing away the surface material, since the introduction of steam no water drains off the surface—it all enters the land and percolates through it, thus materially, by its solvent properties, adding to the fertility of the soil. It is also a well-established fact that land left, after being worked, in the state of porosity in which steam cultivation leaves it, is better in a sanitary point of view when stock come to take up their quarters on it; for it is drier and warmer, and therefore conducive to their health. The influence of long-continued severe weather and sudden atmospheric changes less injuriously effect crops grown on land cultivated by steam power than land cultivated by horse labour, owing to the influence of perfect porosity and the fineness of the tilth, which enables the most delicate rootlet to ramify in all directions unobstructed by the hardness and cohesion of the soil, the plants more firmly establish themselves, and the perfect porosity of the soil renders it less capable of conducting extreme temperatures, which are so destructive in compact and water-logged soils.

Experience has shown that steam cultivated land can be planted in the most unfavourable seasons much earlier than land cultivated by horse labour; and, moreover, on land that has been cultivated by steam power (especially in untoward seasons) the crops have done well and luxuriated, while on the same description of land manipulated by horse power the crops have perished. Also, by the agency of steam we find that root crops have been grown on soil proverbially unfavourable to their growth, and moreover of so superior a quality that the first prize at an agricultural show has been awarded to the crop grown.

Again, steam cultivated land has a great advantage over horse cultivated land, inasmuch as the efficiency of manure greatly depends upon the extent of amalgamation with a perfectly pulverised soil, and therefore the best results are secured where the soil is steam cultivated.

Steam power, as used for the cultivation of the soil, in the present state of the development of the application, is not an entire substitute for horse work; but it will perform the hard work better and cheaper than it can be done by horse power. It is also well known to those who have performed all the hard work of the field by steam power, that a considerable reduction has been made in the number of horses employed, and the horses, which are still required on the farms, are now kept in better condition at a smaller cost. The diminution of the number of cattle required for the cultivation of the soil will lead to a reduction in the quantity of provender required to be grown for them; and therefore the result will be, that a direct increase in the products required for human sustenance may be expected. Apart from the direct saving due to the diminution of the number of horses kept, we must take into consideration the improved character of the cultivation, the perfect command of seasons, and, lastly, the increase in the crops grown, which Mr. Thompson, the president of the Royal Agricultural Society, stated last year would equal "an average increase of eight bushels an acre in the crops throughout the country." The consummation of such results as this cannot be over estimated, and the importance of the question gives it a national character; and in consequence we are led to study the means that have been proposed, and are now adopted, for the successful cultivation of the soil by the agency of steam.

### CLASSIFICATION OF SYSTEMS.

There are four systems that have been proposed for adoption in the application of steam to the cultivation of the soil; and each of these primary systems is capable of further subdivision thus:—

1st Class.—Traction engines, or machines that draw the implements of cultivation after them, which may again be subdivided into—1st, machines that work rotary cultivators; 2nd, machines that drag the ordinary cultivators after them; 3rd, traction engines that are so by means of the power being applied direct to the wheels; 4th, traction engines that are impelled by pushers from behind; 5th, traction engines that are pulled forward to a fixed anchor by the winding of a rope on a drum of the engine, or by the winding of a chain on a grooved pulley; 6th, traction engines that are provided with a movable rail or floor on which it travels; and lastly, traction engines worked upon any of the above principles, but which are impelled by any other power than that of steam.

2nd Class.—Locomotive engines travelling upon fixed railways. This clas may be divided into—1st, machines that drag the implement after them; 2nd, those that draw the implements by means of ropes; and lastly, machines that are propelled by any other agency than that of steam.

3rd Class.—Fixed engines communicating the power to the implements by the agency of chains or ropes. This class may be divided into two divisions; those machines that carry the winding drum, and those on which the windlass is detached from the engine.

4th Class.—Traction engines moving along the head lands or other part of a field and working implements by the agency of wire ropes. This class may be divided into two divisions, or, those in which one engine is used and those in which two engines are used. It may be further subdivided into—1st, those systems that work but one implement; 2nd, those systems that work two implements at the same time; 3rd, those in which two engines are at work at the same time; 4th, those in which but one engine is worked at a time; 5th, those in which the implements travel the full length of the field; and 6th, those systems in which the implements travel over but one-half the length of the field.

*(To be continued.)*

## INSTITUTION OF CIVIL ENGINEERS.

### DESCRIPTION OF THE RIVER WITHAM AND ITS ESTUARY, AND OF THE VARIOUS WORKS CARRIED OUT IN CONNECTION THEREWITH, FOR THE DRAINAGE OF THE FENS, AND THE IMPROVEMENT OF THE NAVIGATION.

By Mr. W. H. Wheeler, M. Inst. C.E.

It was stated that the Witham was originally a tidal river, navigable by ships of considerable size as far as Lincoln, a distance of nearly 40 miles from the estuary. It was this portion of its course, from Lincoln to the outfall, flowing through a low fenny tract of land, and on which the skill of the Engineer had been employed to make it subservient to the purposes of drainage, that formed the subject of this communication.

In the first part of the paper, the ancient history of the Witham, from the time of the Romans to the present day, was traced, and a description was given of the various works upon it. Evidence was adduced sufficient to prove, it was believed—that at one time the surface of the land near the estuary was considerably lower than at present, the level varying from 16ft. to 18ft., at the mouth of the river, to 5ft. at a distance of 20 miles from the sea; that, while it was at this lower level, the land was inhabited and cultivated; that subsequently, it was covered by the sea, and so remained for a number of years, during which time, by the natural action of the tides and the upland water, the soil was gradually raised to its present level; and that the stupendous embankments, by which this vast tract of country was protected from the sea, and on which its safety still depended, were the work of the Romans; for, as every ordinary spring tide must have daily flowed over the land, neither the towns of Boston, Spalding or Wisbeach, which were inhabited by the Saxons, could have been built until the banks were erected. Until, however, about a century ago, notwithstanding all that had been done, the lower lands were still little better than a swamp. The works actually carried out for the recovery of the Lincolnshire Fens draining by the Witham, including the East, West, and Wildmore Fens, near Boston, and the Holland Fen, were next described. Thus, in regard to the Holland Fen, in 1767, the whole of the waters were brought to the orginal outfall at the Black Sluice, by a drain running through the centre of the Fen, its length being upwards of 20 miles, and its depth and width being sufficient to allow of the passage of boats. A sluice was erected at Boston, to exclude the tidal waters, and a lock was built for the purposes of navigation. The total quantity of land drained by this canal, and subject to taxation was 64,395 acres; and, in addition, the drainage of about 30,000 acres, from the Glen and other sources, found its way to the sea by means of the South Forty-foot, as the drain was called. In the year 1846, the drainage being defective, the South Forty-foot drain was lowered from 4ft. to 5ft., on an average, throughout its whole length, with a regular fall of 3in. per mile. A new outfall sluice was built, having three openings of 20ft. each, one being arranged as a navigation lock, and the cill of the new sluice was laid 6ft. below the old one. The whole of this Fen was now in the highest state of cultivation, and the value of the land, which before the drainage and enclosure was hardly worth five shillings an acre, had been increased upwards of six times.

In the year 1751, the decay of Boston haven was attributed to the diversion of waters from the Witham to other sources; thus, by the construction of the North Forty-foot drain, the waters which originally found their way into the Witham were discharged at the Black Sluice, situated below the town, while the West Fen waters were carried to their new outfall at Maud Foster Sluice, placed still lower down the haven. Under the provisions of an Act passed in 1762, a new cut was made, and a sluice erected a short distance above the town (called the Grand Sluice), consisting of four arches, each about 21ft. wide, three being appropriated to drainage, and the fourth being used as a navigation lock; self-acting sea-doors were hung on the outer side of the sluice, and in the interior were 'slackers,' or draw doors, for regulating the height of the water in the river. A new cut or canal was also made for some distance up the river, taking a more direct course than the old channel, and the rest of the river up to Lincoln was widened and deepened. The cost of these improvements amounted to upwards of £60,000. It was then, and had ever since been, found in practice that the drainage and navigation interests were hostile to each other. This was partly remedied by the constitution, under an Act of 1812, of a new cut from Horsley Deeps (Bardney) to Washingborough, with lock-gates for the purposes of navigation, leaving the drainage water to find its way by the old course. Still, however, the navigation seriously interfered with the drainage. In 1864, on the recommendation of Mr. Hawkshaw (Past President, Inst. C.E.,) an Act was obtained, with powers to lower the river for a distance of 23 miles, from the Grand Sluice to Bardney Lock, to a uniform level of 1ft. below the cill of the Grand Sluice, equivalent to 5ft. below the existing cill of the Bardney Lock, and to widen the river to 50ft. at the bottom for about one-half the same distance, gradually diminished to 36ft. at Bardney. This involved the lowering of the cills and chambers of four locks, and the consequent deepening of the canals in connection therewith. It was considered, that by lowering the bed of the upper part of the Witham, the height of the water on the cill of the Grand Sluice could be reduced from 9ft. to 4ft.; that the drainage of the district would be greatly improved; that the silt and other deposits in the haven would be kept lower; that the capacity of the river as a reservoir to receive the waters from the upper districts in times of flood would be considerably increased, the level of these floods being lowered by about 2ft.; and that many of the drains would be able to drain by gravitation, instead of requiring engine power.

The eastern and remaining portion of the Fens, termed the East, West, and Wildmore Fens, were the lowest in level of any in the district. These three Fens together contained about 40,000 acres of land. The late Mr. Rennie having been consulted, as to the best mode of reclaiming and draining this large tract of land, advised that the upland should be separated from the lowland waters, and that for this purpose catchwater drains should be dug, skirting the whole district at the extremity of the Fens, and catching the water as it fell from the higher lands adjacent thereto. These catchwater drains were made to empty into the old Maud Foster drain, at a point about 2½ miles above its outfall, and sluice doors were erected to prevent the upland waters backing into the fen drain. Maud Foster drain was widened and extended, and a complete system of internal drains was carried out in connection with it. The East Fen was drained by means of a new cut of about 14 miles in length, and a sluice for the discharge of the waters into the haven was built at Hob-hole, about 4 miles below Boston. Owing to the cultivation of the land, rendered possible by this thorough system of drainage, and other causes, further works became necessary; and under the direction of Mr. Hawkshaw, two centrifugal pumps, driven by two 90 h.p. engines, capable of lifting 700 tons of water per minute to a height of 5ft., had recently been erected at Lade Bank by Messrs. Easton, Amos, and Anderson. A dam and lock gates being placed across Hob-hole drain, the water could now be lifted out of the upper part of the drain, so as at all times to keep it at a proper level below the surface of the lands in the East Fen.

By means of the several works executed for the drainage of these Fens into the haven, the waters were discharged at various points from 680,392 acres, being the drainage area of the river Witham.

The present state and condition of the haven, as affecting the drainage and the navigation, and the causes which had conduced to its decay, were next considered, and the means proposed and adopted for its improvement were then described.

The basin, or estuary, called the Wash, which received the waters of the Witham, the Welland, the Nene, and the Ouze, was about 300 square miles in extent. It was shallow and full of shifting sands, which were gradually but surely extending and gaining on the sea. The waters discharged from the rivers in times of flood held in suspension large quantities of mud, and meeting with an opposing tidal current, highly charged with silt, a deposit took place, which the back waters were not strong enough entirely to remove. This silting up of the estuary might be further traced to the embanking and enclosing of the lands—the erection of sluices preventing the free flow of water—the improved drainage of the land by means of tiles, and the use of steam power for effecting the more rapid discharge of the waters. Sluices were constructed for, among other things, purposes of navigation. Now it was difficult to combine effectively both the drainage and navigation interests; but, by deepening the channel, it was believed that vessels might pass up with the flowing tide, and return with the ebb. Where the tidal streams could not be made avaiable, it was advisable that there should be separate cuts for the navigation alone. In the Author's opinion, the erection of a sluice across a tidal stream assisted the deposit of silt and mud, instead of preventing it, as was sometimes supposed. The stagnation produced by the sluice also caused the mud to accumulate in the channel against the doors, and so stopped the egress of the waters through the sluice. This had been the case at the Grand Sluice in the Witham, at Boston; and the bed of the river had been raised in proportion, interfering to a considerable extent with the navigation. The erection of the Grand Sluice had been condemned by engineers at the time, and modern engineers took the same view. Mr. Hawkshaw in the year 1861, and again in 1864, had recommended with other works, the removal of this sluice.

The author, in a brief recapitulation of his remarks on this branch of the subject, stated—that all rivers carried with them in their flow large quantities of soil; that wherever the flow was impeded, the soil was deposited on the bottom of the river or estuary; that the tides, meeting the freshes, caused a deposit to take place, and where the back water was not sufficient to wash this away, an accumulation of mud and sand occurred, choking up the outlet and raising the bed of the river; that before Art was brought to bear on the Fens in their natural state, the waters, flowing over the low lands, formed huge reservoirs, which on the return of the tide made the freshes sufficiently powerful to carry out to sea the sand and mud deposited, and to keep the rivers scoured out to their proper depth; that by embanking these lands, and confining the waters to defined channels, the tides became stronger than the freshes, and sand and mud were deposited at the mouths of rivers, hindering their discharge; that further, by the improved drainage causing the rapid discharge of the waters, the freshes were sudden and impetuous, instead of constant and gradual, allowing the deposit brought down by them to be washed back by the tides, and deposited on the beds of rivers, and that this took place to so great an extent as materially to raise the level at the outlet and interfere with the drainage, and that the more the operations of Nature were interfered with the greater was this effect; that wherever sluices or weirs were erected across a tidal river, by causing a longer period of stagnation at the point were the sluice was erected, and preventing the scour of the returning ebbs, a large deposit took place, requiring the whole strength of the winter floods to effect its removal.

The channel for vessels coming to Boston up the Witham was both tortuous and difficult, owing to the numerous shoals and shifting beds of sand. The foreshore of the coast at the point where the Witham debouched was a hard stiff clay, and known by the name of the "Scalp." Along this the water flowed in a south-easterly direction for some distance, and then turned suddenly in a north-easterly direction, the Scalp forming a long elbow round which the waters had to find their course. At this elbow the river Welland joined the Witham, almost at right angles, and both flowed together in one channel for about four miles, when the united streams again divided into two. The greatest hindrance to the discharge of the waters occurred at this elbow, where the Witham and Welland spread themselves over a wide and unconfined space, and so lost their velocity, and with it the power to move the sands and mud accumulated during the summer months. Owing also to the long winding course of the Witham round Elbow Point, a distance of four miles (the direct course across this clay foreshore being only two and a quarter miles), there was a great loss of fall. Thus, while at Hob-hole Sluice, about three miles above the bar, there was seven feet of water at low water, and in Clayhole, about one mile below Elbow Point, it was ten feet, at the bar there was not more than ten inches. The removal of this bar, and obtaining a greater fall, had been the aim of all the engineers who for the last one hundred and thirty years had reported upon the haven. One course had been invariably recommended—the making of a new cut through the clay foreshore, about one and a quarter mile in length, confining the water to this channel, and training the Welland with fascine work through the shifting sands to a junction with the Witham in Clayhole. The course of the Witham would thus be shortened about a mile and three quarters, and being confined by the embankments and fascine work, would not have such a great body of shifting sand to contend with, and would be at once carried to deep water in Clayhole. This would allow all the flood waters from the several sluices to be properly discharged, and give a general relief to the low lands of the Fens. It had been estimated that the total expense for the Witham Channel would be about £60,000, and for the Welland Channel about £20,000. By carrying out this plan, many acres of land, at present covered by the tide, would in course of time be warped up and become good marsh land.

Reference was then made to the works carried out in the year 1825, under the advice of Sir John Rennie (Past President Inst. C.E.), at a cost of about £40,000, by which the channel between Skirbeck Church and Hob-hole Sluice had been straightened, and the course of the river had been contracted. Thirty years after the commencement of this work, 300 acres of the reclaimed land had been sold for £10,000, and had been embanked by the purchaser; while a few years ago, two other marshes had been embanked by the Commissioners, and had been let on lease at a rental of £310 per annum, the area, including foreshore and bank, being about 160 acres.

The system of parallel training walls, constructed of faggots, clay, and chalk, had been adopted to a great extent for the Fen rivers, and had been found to answer better than any other plan. The manner in which these training walls had been carried out, on the rivers Witham and Welland, was then described.

In conclusion, the general results of the enclosure of the Fens were briefly reviewed; and it was observed that the appearance and prosperity of this large tract of land, equal in extent to many counties, when contrasted to what it was a century ago, was a striking proof of the ingenuity and industry of man, and reflected the highest credit on the skill of the engineer, and the enterprise of the people.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

### CHIEF ENGINEER'S MONTHLY REPORT.

"Wigan Coal Trials.

"I have now the pleasure of presenting to our members condensed tables of the results obtained at the first series of Wigan Coal Trials, referred to in the monthly report for July last, as well as a brief account of the mode of conducting the experiments. The special object of this series of trials was to show the suitability of the South Lancashire and Cheshire coals for use in Her Majesty's Navy. The trials were carried out at the expense of the South Lancashire and Cheshire Coal Association, under the superintendence of the late Dr. Richardson, of Newcastle, and myself, and it is with the permission of that Association that these particulars are presented to our members.

"I propose to describe in the first instance the mode of conducting the investigation with the testing apparatus employed; in the second, the preliminary trials with the modifications in the furnaces and treatment of fires arrived at; and in the third, the permanent trials with their results.

"1. Description of the Mode of conducting the Trials and of the Testing Apparatus employed.

"The principle on which these trials were conducted was simply that of ascertaining by practical experiment in a steam boiler how much water 1lb. of coal would evaporate, also at what speed that could be done, and whether with or without the formation of smoke. To this end all the water evaporated was accurately measured; the coal carefully weighed; and the time expended in doing a given amount of work noted; added to which the amount of smoke emitted was observed and registered.

It may be well to describe more in detail the mode adopted for measuring the water and weighing the coal, as well as the boiler employed and the method of estimating the amount of smoke.

"Measurement of the Water.—Water meters are not always to be relied on, and therefore to avoid every chance of mistake, or even suspicion of inaccuracy, a tank was employed of sufficient size to carry through an entire experiment with a single charge. This tank, which had a superficial area of 50 square feet, and thus a capacity of 260½lbs. per each inch in depth, was fitted with a float, which, reposing on the surface of the water, rose and fell with it, and operating upon a pointer, travelling over a scale graduated in feet and inches, indicated the precise amount consumed, as well as the rate of progress throughout the trial.

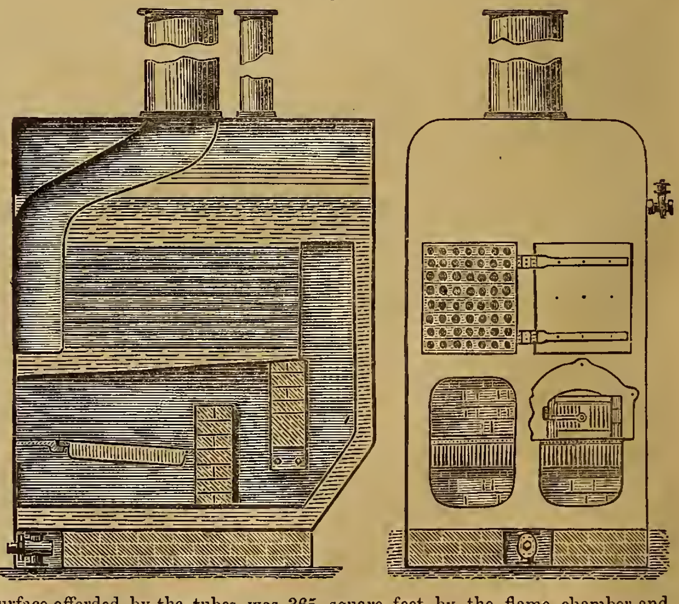
"It is usual in such trials to evaporate the water at atmospheric pressure, so as to afford a common standard for the comparison of different experiments, while it has the further advantage of dispensing with the necessity of a pump, and of very much reducing the chances of waste from leakage. The plan had been adopted by the Admiralty in previous trials, and therefore was followed on the present occasion. The tank was placed at a short distance from the boiler, and at a sufficient height for the water to flow into it by its own weight, the two being connected by a pipe 2in. in diameter, which was fitted with a stop tap, so that the supply could readily be controlled by hand, while the whole was placed so as to be quite open to view, so that no loss from leakage could go on unobserved.

"The feed water was supplied to the boiler at its natural temperature, whatever that might happen to be, but as this varies at different times, and clearly affects the result, it is important that an allowance should be made for these variations so as to admit of the correct comparison of different experiments. It is, therefore, customary to qualify the amount of water evaporated, by the temperature of the feed, and to reduce it to a standard of so many lbs. of water evaporated from a temperature of 212° or 100° as may be decided on. As the standard of 100° had been adopted by the Admiralty in previous experiments, it was adhered to on the present occasion, and the necessary qualification made.

"Mode of Weighing the Coal.—The coal was weighed in charges of 200lb. and shot down in front of the boiler so as to be kept entirely distinct from the general stock.

"Description of the Test Boiler.—As these trials had special reference to the suitability of the coals of this district for steam purposes on board Her Majesty's Navy, a boiler of the marine multitubular type was adopted; and, further, as a special one is employed at Her Majesty's Dockyard Keyham, for testing the value of coals, it was proposed by Dr. Richardson that to avoid all question a precisely similar one should be used for the Wigan trials, and with this view a fac-simile of the Keyham test boiler was made from drawings kindly furnished by T. W. Miller, Esq., chief engineer at Her Majesty's Dockyard, Keyham. This boiler was of very cramped proportions, and by no means calculated to develope the highest results from the coals, but it was adhered to for the reasons just given. It measured 7ft. 8in. in length, 8ft. 10in. in height, and 5ft. in width, and contained 124 flue tubes, 5ft. long and 2¼in. diameter inside, with two furnaces each 1ft. 8⅛in. in width. The heating surface afforded by the tubes was 365 square feet, by the flame chamber and surnaces, including the ashpit, 128 square feet, making a total of 493 square feet of heating surface. The equipment of the furnaces was of the usual class,

Fig 1.



consisting of an ordinary fire door, dead-plate, set of fire bars, and single vertical brick fire bridge, the fire door being fitted with a sliding grid for the admission of air when required, and a perforated box at the back for the dispersion of the current. To give a better idea of the proportions of the boiler with the furnace mountings two cuts are appended, the first of which gives a longitudinal section through one of the furnaces, the other a front external elevation, added to which there is subsequently given an enlargement of the fire door.

"Method of Estimating the Amount of Smoke.—To accomplish this, an observer watched the chimney throughout the whole experiments, and noted every minute in which smoke occurred, the density being defined by gradations of 1, 2, 3, 4, 5, 6.

"In the tables accompanying this report, however, the six gradations just given are reduced to three for the sake of simplicity, under the designations of '*very light*,' '*brown*,' and '*black*.'

### "2. Preliminary Trials with the Modifications Made in the Furnaces and Treatment of the Fires.

"At the commencement of the trials only 8.01lb. of water were evaporated by 1lb. of coal, and 35.81 cubic feet of water by the boiler per hour, with a consumption of 20lb. of coals per hour per square foot of fire grate; subsequently, however, the results were considerably improved, and 11.11lb. of water were evaporated by one of coal, with a speed of 46.19 cubic feet of water per hour, and 25lb. of coal per hour per square foot of fire grate.

"This improvement was obtained simply by slight modifications in the proportions of the furnaces and treatment of the fires.

"It would be interesting to trace all these modifications, and to give the results of each. This, however, would be a work of too great length for the present occasion. Suffice it therefore to say, that 115 preliminary experiments were made, during which it was found of advantage to reduce the length of the fire grate from 4ft. to 3ft. to adopt a blind dead plate in preference to a perforated one, and to slightly lower the level of the fire grate so as to increase the flame chamber above the bars, while there is no doubt that a further advantage would have been gained by lowering the bars still more had not the ashpit become thereby too cramped for the due admission of air. No bar was found to give a better result than a wrought-iron one an inch thick with half-inch space as windage, while the addition of an inverted or hanging bridge behind the ordinary vertical one was found of advantage in preventing smoke, its action being to assist in mixing the gases and maintaining the temperature of the furnaces.

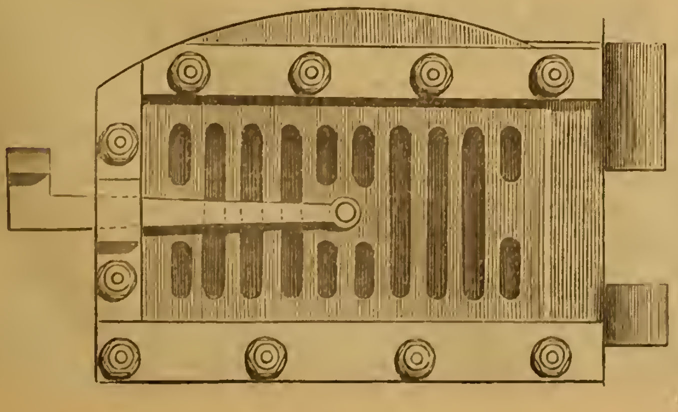
"The following figures will show the result of its working:—

*Comparative Table of results with and without Inverted Bridge.*

| NAME OF COAL AND CHARACTER OF TRIAL. | lbs. of Water at 100° evaporated per lb. of Coal. | Cubic feet of Water at 100° evaporated per hour. | Smoke per hour. | | |
|---|---|---|---|---|---|
| | | | Minutes of Very Light. | Minutes of Brown. | Minutes of Black. |
| Haigh Yard Coal with Inverted Bridge... | 11·24 | 47·38 | 0·5 | 0 | 0 |
| Ditto without Ditto ... | 11·05 | 51·31 | 2·5 | 0 | 0 |

"The number of perforations for the admission of air through the fire doors were also modified. In the first instance there were 730 giving an area of 3·2 square inch per square foot of fire grate. These were afterwards reduced by bolting a blank plate over the lower part of the doors so as to make the number of perforations 342, equal to an area of 1·6 square inches per square foot of fire grate. It is thought that the benefit from this change arose more particularly from the alteration in the point of admission, and it was afterwards found necessary with the thickest fires to leave the doors 1in. or 1½in ajar for a minute or so after firing to prevent the formation of smoke.

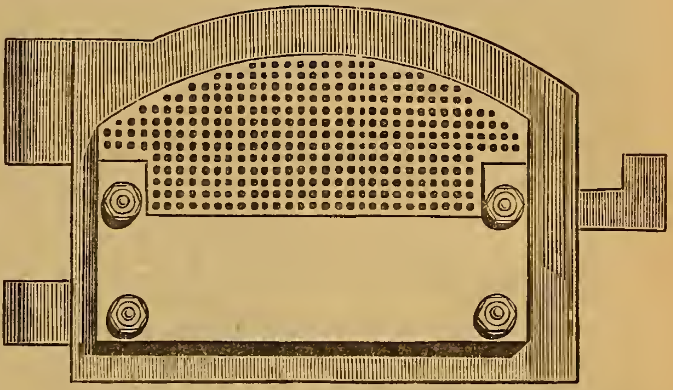
Fig. 2.



"The proportions of the furnaces finally adopted, with the length and level of grate and arrangement of fire bridges, are those shown in the cuts of the boiler already referred to, while the following enlarged view of the fire door will show its general construction and the final number of perforations:—

"In addition to the modifications in the proportions of the furnaces, two modes of firing were adopted, one termed 'spreading,' the other 'coking.' In 'spreading' firing the coal is scattered evenly over the whole surface of the fire grate, commencing generally at the fire bridge and working forward to the fire door. In 'coking' firing, the charge of coal is thrown on to the dead plate in front of the bars and allowed to lodge there for a time in order that the mass may become coked through, and when that is done, the crest is pushed back towards the bridge, and another charge thrown on to the front of the fire in its place. In this way the gases are gradually evolved from the coal at the front while a bright fire is maintained at the back over which the gases pass. On trying the two plans, coking firing was found to give a more economical result than spreading, and at the same time to produce less smoke, while, in addition, a higher result was obtained by thickening the fire from 6 to 9in. and again from 9 to 12in.

Fig. 3.



"'Coking' firing was therefore adopted as the standard method, and with fires 12in. thick, while the furnaces were charged alternately and the perforations allowed to remain open for a few minutes after charging for the prevention of smoke.

### "3. Permanent Trials and their Results.

"The preliminaries just described having beeen determined, fifteen coals selected by H.M. Inspectors of Mines, Joseph Dickinson, Esq., and Peter Higson, Esq., were then submitted to trial *scriatim*. The following is a list of their names:—

Handley Yard.
Worsley Top Four Feet.
Upper Crumbouke.
Lower Crumbouke.
Upper Three Yards.
Six Feet Rams.
Great Seven Feet.
Blackrod Yard.
Pemberton Little Delf or two Feet Mine, and Pemberton Four Feet Mine, where the two are so near together as to form one seam.
Haigh or Arley Yard.
Furnace Mine.
Bickerstaffe Four Feet or Blnugate Mine.
Rusby Park and Little Delf Mines worked simultaneously and mixed.
Iuce Three Feet, Four feet, and Seven Feet Mines, worked simultaneously and mixed.
Arley Mine.

"Although it had already been found that thick firing gave better results than thin, yet as the whole of the preliminary trials had necessarily been made with one coal for the purpose of comparison it was thought desirable to test all the coals on the list with various thicknesses of fires rather than to assume they all required precisely the same treatment, and therefore they were tried with fires 9in. thick and then with 12in. thick, the latter being thought at first the greatest thickness permissable, but experience showing that 14in. fires could be managed, additional samples of the coals where necessary were procured, and further trials made with 14in. fires. Added to this, a longer trial was made, in which 1,500lbs. of coal was burnt instead of 1,000lbs. as in others, in order to see how far the coal would maintain its efficiency in a long run. Also the effect was tried of closing the perforations in the fire doors as an indication whether too much air had been admitted or not. In all the trials just named the "coking" system of firing was adopted, but an additional one with "spreading" firing 12in. thick was made as a comparison, and as it was found in all cases that coking firing proved to be the most economical. further trials on the spreading system were thought unnecessary.

"The result of these trials showed that the coals possessed a very high evaporative power combined with great speed; one coal evaporating 11·10lb. of water at 100° per lb. of coal; a second, 11·15lb; a third, 10·49lb; a fourth, 10·91lb. &c., &c.; while in the case of the first, 46·17 cubic feet of water were evaporated by the boiler per hour; in the second, 48·60 cubic feet; in the third 51·34 cubic feet; in the fourth, 45·37 cubic feet; while only a little faint smoke was occasionally visible. These results were very superior to those reported to the Admiralty in 1849 by Sir Henry De la Beche and Dr. Lyon Playfair, who returned the economic evaporating power of the best of the Lancashire coals as only equal to 8lb. of water at 100° evaporated by 1lb. of coals. The results obtained from the South Lancashire and Cheshire coals were found to compare very favourably with those obtained from the North Country and Welsh coals at Her Majesty's Dockyard, Keyham, but it was thought it would be of further satisfaction to try the Welsh and Newcastle coals in the Wigan boiler for comparison, and this was therefore done. The results will be more readily seen if arranged in the form of a table, as follows;—

*Comparative Table of the results of the trials of the North Country, the Welsh, and the South Lancashire and Cheshire Coals.*

| NAME OF COAL AND PLACE OF TRIAL. | lbs. of Water at 100° evaporated per lb. of Coal. | Cubic Feet of Water at 100° evaporated per hour. | Smoke per hour. Minutes of Very Light. | Smoke per hour. Minutes of Brown. | Smoke per hour. Minutes of Black. |
|---|---|---|---|---|---|
| *North Country Coal.* | | | | | |
| Davidson's mixed with Hasting's Hartley, in equal quantities. Tried at Keyham | 10·71 | 43·00 | 3·4 | 0 | 0 |
| Ditto Tried at Wigan... | 10·71 | 51·33 | 1·3 | 0 | 0 |
| *Welsh Coal.* | | | | | |
| Powell's Duffryn mixed with Nixon's Navigation and Davis's Abercwomboy, in equal quantities. Tried at Keyham | 10·14 | 30.60 | 3·1 | 0 | 0 |
| Ditto Tried at Wigan... | 11·15 | 48.60 | 1·7 | 0 | 0 |
| *South Lancashire and Cheshire Coals.* | | | | | |
| Hindley Yard Coal. Tried at Wigan ... | 11·10 | 46·17 | 0·2 | 0 | 0 |
| Lower Crumbouke Coal. ditto ...... | 11·15 | 48·60 | 1·8 | 0 | 0 |
| Great Seven Feet Coal ... ditto ...... | 10·49 | 51·24 | 5·9 | 0 | 0 |
| Blackrod Yard Coal ...... ditto ...... | 10·91 | 45·37 | 2·4 | 0 | 0 |
| Haigh Yard Coal ......... ditto ...... | 11·24 | 47·38 | 0·5 | 0 | 0 |

"Detailed results of the permanent trials of the whole series of coals, when treated on the coking system, with the fires 14in. thick, and the perforations in the doors intermittently open—which were the conditions that afforded the highest results—will be found in the tables appended (see Sheets 1, 1a, 1b); but as the detailed tables of the remaining trials—made under various conditions as to the thickness and treatment of fires, admixture of air with the gases, and length of experiment—occupy as many as 38 sheets, it was found impracticable to include them *in extenso* in this report, but the condensed results are subsequently given.

"When all the coals on the list had been tested, and the results given in the tables just referred to arrived at, the Admiralty sent down two of their officers, Robert Nicoll, Esq., R.N., Assistant to Chief Engineer at H.M. Dockyard, Keyham, and William Lynn, Esq., Assistant Inspector of Machinery at H.M. Dockyard, Portsmouth, to witness a repetition of the trials, and report thereon. A table giving the results obtained by the Admiralty officers will be found on sheet No, 2.* All the trials hitherto referred to were made with the natural chimney draught, but it was thought well for the Admiralty officers to witness a second series with the draught quickened by mechanical means, and therefore a steam jet fed by an adjoining boiler at a pressure of 30lb. per square inch was applied to the chimney. A table giving the results of this second series of trials by the Admiralty officers will be found on sheet No. 2a.

"To facilitate a comparison between the results of the original series of trials and of the verifications by the Admiralty officers, sheet No. 3, has been prepared, which gives in parallel columns the net results of the different trialf of each of the coals on the list, while the following tables gives the mean of the whole.:—

*Table of the mean result of all the South Lancashire and Cheshire Coals experimented on.*

| CHARACTER OF TRIAL. | lbs of Water at 100° evaporated per lb. of Coal. | Cubic Feet of Water at 100° evaporated per hour. | lbs. of Coal burnt per hour per Square Foot of Fire Grate. | Smoke per hour. Minutes of Very Light. | Smoke per hour. Minutes of Brown. | Smoke per hour. Minutes of Black. |
|---|---|---|---|---|---|---|
| Mean results of all the coals tried by Dr. Richardson and Mr. L. E. Fletcher | 10·35 | 47·32 | 27 | 2·4 | 0 | 0 |
| Ditto verified by Admiralty Officers ...... | 10·68 | 48·30 | 27 | 1·1 | 0 | 0 |
| Ditto with steam jet tried by Admiralty Officers ........................................ | 10·18 | 69·13 | 41 | 0·0 | 0 | 0 |

"This table shows that the Admiralty officers more than verified the results previously given, and in reporting to the Admiralty thereon they stated that such was the case.

"Further to test the value of the coal it was thought well to have a trial at sea, and therefore a run was made with the *Lindsay*, a screw collier of about 800 tons burden fitted with two boilers each containing three furnaces and driving a pair of engines having a diameter of 28in. in the cylinder, making 70½ revolutions per minute and indicating about 460 horse power. The trial was most satisfactory; coking firing, as already explained, was adopted and carried out by the ordinary ship's stokers, and Messrs. Nicoll and Lynn report that steam 'was kept blowing off at the waste steam pipe all the time of the trial while no smoke was visible during the whole of the four hour's run.' The commissioners close their report with these words, 'in conclusion these experiments, including that of the *Lindsay*, show that when the products of the coal are consumed, which we consider can be easily done by careful firing, the coals of this district have a high evoporative value, combined with great speed, and are in every respect fit for Her Majesty's Service.

"To assist in estimating the advantages of different thicknesses of firing, sheet No. 4 has been prepared, which gives the results of firing each coal with a thickness of 14, 12, and 9 inches. The following table gives the mean results of the whole number of coals at each thickness of fire:—

*Comparative Table of the result of different thicknesses of fires.*

| CHARACTER OF TRIAL. | lbs. of Water at 100° evaporated per lb. of Coal. | Cubic Feet of Water at 100° evapotated per hour. | lbs. of Coal burnt per hour per Square Foot of Fire Grate. | Smoke per hour. Minutes of Very Light. | Smoke per hour. Minutes of Brown. | Smoke per hour. Minutes of Black. |
|---|---|---|---|---|---|---|
| Mean Results of all the Coals, with Coking Firing. Fires 14in. thick ... | 10·35 | 47·22 | 27 | 2·4 | 0 | 0 |
| Ditto „ 12in. thick .. | 10·06 | 45·67 | 27 | 2·8 | 0 | 0 |
| Ditto „ 9in. thick ... | 9·65 | 44·00 | 27 | 1·0 | 0 | 0 |

"From this it will be seen that a fire 14 inches thick gives a more economical result than one 12 or 9 inches thick, while no diminution of speed is experienced.

"To show that 'coking' firing coupled with the admission of a little air above the bars immediately after charging, which is the smokeless system, is not attended with any loss in economy, sheet No. 5 has been prepared, which gives the result of three different systems of treatment applied to each coal:—1st, the 'coking' system coupled with the admission of sufficient air above the bars to prevent smoke. 2nd, the 'coking' system with perforations in the fire door closed; and 3rd, the 'spreading' system with the perforations in the

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* These sheets are omitted as being of no general interest, the Tables of mean results which follow giving all that is necessary.—Ed. Artizan.

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fire door open after charging. The following is the mean result of each of the three systems:—

*Comparative Table of the result of firing of the Coking and on the Spreading Principle, and also of admitting air at the fire door or not.*

| CHARACTER OF TRIAL. | lbs. of Water at 100° evaporated per lb. of Coal, | Cubic Feet of Water at 100° evaporated per hour. | lbs. of Coal burnt per hour per Square Foot of Fire Grate. | Smoke per hour | | |
|---|---|---|---|---|---|---|
| | | | | Minutes of Very Light. | Minutes of Brown. | Minutes of Black. |
| Coke firing with fires 12in. thick. Perforations in fire-door open after charging ........................ | 10·13 | 46·36 | 27 | 3·2 | 0·0 | 0·0 |
| Coking ditto with perforations constantly closed ........................ | 9·75 | 47·03 | 29 | 12·6 | 1·4 | 0·6 |
| Spreading ditto with perforations in fire door open after charging ............... | 9·51 | 51·37 | 32 | 20·8 | 5 3 | 4·2 |

"A consultation of this table will show that there is no loss in economy from adopting the smokeless system of firing. but on the contrary, a slight gain, though there is a loss of speed, neither as much coal being burnt per square foot of fire-grate nor as much water evaporated per hour from the boiler. Thus the table shows at once the advantage and difficulty of smoke prevention. It is feared that difficulty will be experienced wherever boilers are overtasked, while it will be seen that the table affords an explanation of the objection entertained by firemen to admitting air above the fire bars when they want to raise steam quickly.

"On making a longer trial, that is to say, consuming 1,500lb. of coal instead of 1,000lb., and running for an average length of time of 5h. 9m., instead of 3h. 27m., the result was slightly inferior in economy, though practically equal as regards the amount of water evaporated by the boiler per hour and the absence of smoke. The precise figures are given in the following table:—

*Comparative Table of the result of short and long trials.*

| CHARACTER OF TRIAL. | Average length of trial. | Amount of Coal consumed. | lbs. of Water at 100° evaporated per lb. of Coal. | Cubic Feet of Water at 100° evaporated per hour. | lbs. of Coals burnt per hour per Square Foot of Fire Grate. | Smoke per hour. | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Minutes of Very Light. | Minutes of Brown. | Minutes of Black. |
| | H.M. | | | | | | | |
| Short trial ...... | 3.27 | 1,000 | 10·29 | 46.81 | 27 | 2·4 | 0 | 0 |
| Long trial ...... | 5.9 | 1,500 | 9·76 | 45·71 | 28 | 2.0 | 0 | 0 |

"It may be added that in this series of trials the fires were treated on the coking system, as before, and that in some cases they were 14 inches thick, in others 12 inches, and in one 9 inches—care, however, being taken in quoting the result of each coal that the thickness of fire should be the same in the short trials as in the long so that the comparison is a correct one.

"Such is a very brief account of the series of trials of the South Lancashire and Cheshire coals. It will be seen, however, that these coals have a high evaporative value combined with great speed, some of them as returned by the Admiralty officers—who were sent down to investigate and report—being able to evaporate 11.312. of water, at a temperature of 100 per lb. of fuel at a speed of 26lb. of coals consumed, and 4.7 cubic feet of water evaporated per square foot of fire grate per hour, while the mean of the fifteen coals tried, gives an evaporation of 10.68lb. of water at 100 per lb. of fuel at a speed of 27lb. of coal burnt and 4.7 cubic feet of water evaporated per square foot of fire grate per hour.

"Since these trials, as previously stated, had special reference to the suitability of the South Lancashire and Cheshire coals for use in Her Majesty's Navy, round coal was used almost entirely and not slack. These trials, therefore do not exhaust the whole subject of the economy of fuel with regard to mill purposes, yet it is thought there are several points in them which are of general interest, and that the circulation of information with regard to them will prove of assistance to the ordinary steam user. It is of interest to note that the free burning and gaseous coals of this district were burnt in these trials with the entire absence of any smoke beyond the faintest trace, and that this was accomplished both at sea and on land and that, not by means of any special apparatus, but simply by careful firing, accompanied by the admission of a little air through the fire door, for a short time after charging. It should be also noted that the economy was the result of this smokeless system of firing, and of the admission of air through the fire door, also that thick fires were found to be more economical than thin, and short fire grates than long ones, and though due regard must be had to the amount of steam required, yet it is thought the fire grates in ordinary use in mill boilers are, as a rule, too long.

[*The remainder of the Tables will be given in our next.*]

## ROYAL GEOGRAPHICAL SOCIETY.

The Meeting was honoured by the attendance of His Excellency Said Mahommed bin Salim, Said Ahmed bin Suleiman, and Hadji Mahommed Bakushmeer, Special Envoys from the Sultan of Zanzibar to the British Government. In welcoming them the President mentioned that Dr. Livingstone had been aided during his present expedition by supplies sent him by the Sultan of Zanzibar. The following Paper was read:—'Travels in Manchuria,' by the Rev. Alexander Williamson. The author gave a description of this little-known region lying to the north-east of China Proper, and which he had traversed in various directions during the years 1864, 1866, 1867, and 1868. The country resembled Canada in its climate and productions, but was superior to it in mineral wealth, and in its seaports in the Gulf of Liau-tung being open all the year round. The eastern side was very mountainous, the slope of the country being towards the west and north, in which latter direction flow its great rivers—the Usuri, the Sungari, and the Hurka—tributaries to the Amur. The Shan-Alin range, on the east, rises to a maximum altitude of 12,000ft, and the summits are clothed with perpetual snow. The rivers in the southern parts are generally frozen over by about the 20th November, and are not navigable again before the middle of March. In summer the temperature varies from 70° to 90°; the crops ripen in a few months, and by the end of October everything is safely housed. The bulk of the inhabitants are Chinese immigrants, or descendants of immigrants, from the northern provinces of China. They have settled in all the principal places, and the present Government encourages them by selling them land at nominal prices, so that the immigration increases year by year. The Manchus are generally agriculturists, and in dress, customs, and language difficult to be distinguished from the Chinese. The nomadic propensity in the Manchus seems to have died out. Southern Manchuria contains a population estimated at 12,000,000; Central Manchuria has from 2,000,000 to 3,000,000. Many of the large towns are well built, the streets well laid out, and full of good shops. In the capital of the province the author saw several large booksellers' shops, speaking well for the literary tastes of the people. In the southern parts the Manchu language was but little cultivated. Some few only of the more aged now speak it, and the rising generation are taught from Chinese books in their schools. In some places youths are instructed in the Manchu character after they are acquainted with Chinese, but such instances are rare. Cotton is grown, in several places, in considerable quantities; and common coarse silk is produced in great abundance. In addition to these, indigo and tobacco, besides wheat and other products of temperate latitudes, are grown. The mineral wealth is great; coal prevails extensively in many parts of the country; one of the chief coal-districts lies on the north-east of Laou-Yang. Gold is found on the east coast of Southern Manchuria, where the auther passed over a district of gold-diggings 40 miles in length by 10 miles broad. Iron is also very abundant.

An animated discussion followed the reading of the paper, in which Mr. J. McLeavy Brown, Secretary to the Chinese Legation, General Sir Hope Grant, and Mr. W. Lockhart took part.

The following gentlemen were elected Fellows of the Society:—Henry Blanc, M.D.; W. Bowly; H. Bright; G. P. Bevan; Hon. F. Bedingfeld; W. Clarke; T. T. Carter Lieut. R.E.; A. Croll; A. A. H. Currie; W. P. Duff; John Douglas; W. H. M. Dougall, Capt. R.N.; G. W. Davidson, M.D., &c.; Rev. T. A. Edwards, M.A.; Lieut.-Col. G. M. B. Farquharson; A. Frater; R. H. Glyn; T.H Holdich, Lieut. R.E.; J. Lawrie; R. P. Linton; J. L. Lobley; R. McLaren; Major F. A. Millingen; Lord Ormathwaite; T. S. Owden; Lieut. W. F. Prideaux (Bomb. Staff Corps); H. Rose; Major-General Sir Charles Staveley, K.C.B.; Major R. M. Smith, R.E.; J. de Salles; C. H. Walker; Rev. T. Whitby, M.A.; R. H. Wood; Capt. J. Wood (late I.N.).

## REVIEWS AND NOTICES OF NEW BOOKS.

*Personal Recollections of English Engineers.* By A CIVIL ENGINEER. London: Hodder and Stoughton.

SELDOM have we met with so pleasant a book as these personal recollections. The author, who has evidently been himself employed upon many important engineering works, has thereby come in contact with most of those men who, by their talent and energy, raised themselves to the highest eminence in the profession. In being constantly in contact with these men while in the midst of carrying out some of their most important undertakings, the author has had the best possible opportunities for observing their real character and picking up original anecdotes respecting them. These observations and anecdotes the author has now embodied in a work which gives most pleasant reminiscences of Stephenson and others, now beyond the reach of praise or attack, together with many well known living engineers, who are often easily recognised by their portraits so pleasantly delineated in words. In those cases, however, where unfavourable features have been unavoidably drawn, the author has most properly so disguised that not even his intimate friends would know him.

# NOTES AND NOVELTIES.

## MISCELLANEOUS.

Mechanical Industry in Italy.—One of the most important mechanical establishments in Southern Italy is that of Pietzarsa, at Naples, belonging to the Societa delle Industrie Meccaniche. These works employ about 1250 persons, and are furnished with 300 machine tools driven by nine steam engines, amounting in all to 88-horse power. At this establishment they make locomotive carriages and every description of railway plant, iron bridges, boilers, cranes, pumps, war material, and marine engines up to 500-horse power.

Experiments on Gunpowder.—A series of experiments on gunpowder is at present being carried out at Woolwich by the Ordnance Select Committee with the new chronoscope for measuring the velocity of projectiles within the bore of the gun, invented by Captain A. Noble, late of the Royal Artillery. The results hitherto obtained are preliminary, but have been attended with great success. The instrument has proved itself capable of measuring the hundred-thousandth part of a second with great accuracy.

The Board of Trade returns for the ten months ended the 31st October show that the total amount of exports from the United Kingdom during that period was £150,681,161, against £153,051,639 in 1867, showing a decrease of £2,370,478. The import returns, which are only brought down to the end of September, show an important increase, not only upon those of all the previous months of the year, but also upon the corresponding periods of 1866 and 1867. The total value amounted to £23,386,646, which was upwards of three millions sterling in excess of the value recorded in August.

The arrangements for the purchase of the telegraphs by the Government are being actively carried on, and a Commission appointed by the Accountant-General has nearly concluded the inquiry into what the net profits of the companies really are. A complete collection of the instruments used has been arranged in the library of St. Martin's-le-Grand. It is said to be a most interesting display, and one which shows in a remarkable manner the vast progress which has been made since the first application of electricity to the purpose of telegraphy.

Cotton in Queensland.—A Brisbane paper says: "There is a growing impression that this staple is one of the safest, if not the most remunerative, that Queensland growers can invest in. Confidence is felt in the crop as experience is gained, and it is found that, instead of 5 or 6 acres, a family can manage 20 or 30. There is much uncertainty in the colony on the best methods of ginning. English brokers have represented that the Queensland staple is cut and broken in the ginning process, and recommend roller instead of saw gins. Experienced men in the colony, who know how cotton is turned out in America, India, and elsewhere, maintain that the picking, sorting, and ginning of Queensland cotton is remarkably well done, and that the fault of irregular staple is owing to the mixed seed used in the colony, and that the gins break it here no more than they do in other countries."

Glass Works in the Neapolitan Provinces.—The manufacture of glass in the Neapolitan provinces has of late years fallen off considerably, owing to the proprietors not being willing to keep pace with the times, and not having introduced modern improvements in this branch of trade. The most important glass works in the provinces of Naples and Salerno are those of Portica San Giorgio, near Cremano, and Bagnoli; these establishments employ 232 workmen, and produce annually about 30,000 metrical quintals of sheet glass. At the Portici works a Siemens furnace has been lately introduced; the other works, however, have not yet abandoned the old fashioned furnaces.

The new system of working hours directed by the Admiralty for adoption in the royal dockyards came into operation at Sheerness on the 1st inst.

An order for hydraulic apparatus of the value of about £8,000 has been given out to Messrs. W.G. Armstrong and Co., of Newcastle-on-Tyne; the apparatus is required for docks at Antwerp. The Cockerill Company is stated to have delivered a lower tender, but the contract was let to Messrs. Armstrong, as it was considered that they would be able to proceed with it more expeditiously.

New Gas Lamp.—A new lamp, of French invention, is thus described:—Coal gas, intimately mixed with air, is urged with gentle pressure along a tube, and made to pass through a metallic plate pierced full of minute holes. By this means a vast number of jets are obtained, which, after being driven through a fine tissue of platinum wire, are lighted in the ordinary way. The platinum soon acquires a white heat, and gives out so brilliant a light that it cannot be supported by the naked eye. About one metre of gas is consumed per hour.

## MILITARY ENGINEERING.

Mr. A. M. Stevens, of Owen Sound, Canada, has an improved Snider breech-loading rifle, which is now being exhibited at Montreal, in which the motions are reduced to three—cocking, loading, and firing. It is said to be capable of discharging 40 rounds a minute.

## SHIPBUILDING.

Steam Shipbuilding on the Clyde.—Messrs. Tod and M'Gregor, of Paitick, have launched a screw named the *City of Brooklyn*, built for the Liverpool, New York, and Philadelphia Steamship Company. The dimensions of the *City of Brooklyn* are as follows:—Length over all, 370ft.; breadth, 42ft.; depth, 28ft. 6in.; and burden, 3,000 tons, builders' measurement. The steamer will be propelled by horizontal direct-acting surface-condensing engines of 450-horse power, nominal, working up to 2,000-horse power. The *Hibernia*, recently lost on her passage from New York to Glasgow, was built at Glasgow, in 1865, by Messrs. Alexander Stephens and Sons. Her gross burden was 1,616 tons, and her engines were of 350-horse power. She was owned by Messrs. Handyside and Henderson and was one of the well-known Anchor line of steamers.

Iron Shipbuilding at the Tees and at Hartlepool.—At Stockton, Messrs. Richardson, Duck, and Co., have in hand one sailing ship 1,367 tons register, dimensions 210ft. long, 37ft. beam, and 23ft. in depth; one screw steamer 1,050 tons, dimensions 220ft. by 16ft. 6in.; one screw steamer 1,203 tons, dimensions 240ft. by 32ft. by 19ft. 6in.; one screw steamer 1,400 tons, dimensions 258ft. by 32ft. by 20ft.; one screw steamer 461 tons, dimensions 165ft. by 24ft. by 14ft.; two barges 68 tons each, dimensions 75ft. by 20ft. by 6ft.; one barge 97 tons, dimensions 90ft. by 15ft. by 7ft., making a tonnage of 5,846 tons. Messrs. Pearse and Co., Stockton have the following vessels on hand:—One screw steamer 210ft. by 30ft. by 22ft. 6in., 919 tons, 135-horse power, sold to Antwerp; one barque 105ft. by 24ft. by 14ft. 277 tons, for Bilhoa; one sailing ship, 185ft. by 30ft. 6in. by 19ft. 6in. 824 tons, for Liverpool. Messrs. Denton, Gray, and Co., Hartlepool, are building an iron sailing ship 900 tons register, four steamers of 700 tons each, and one steamer of 600 tons. During the present year, the same firm have launched one iron sailing ship 500 tons, one composite do. 700 tons, three steamers 700 tons each, one steamer 935 tons, and one steamer 600 tons.

Steam Shipbuilding on the Clyde.—The *Deccan* screw, the latest addition made to the fleet of the Peninsular and Oriental steam Navigation Company, has made a favourable trial trip. She was built by Messrs. W. Denny and Brothers. Messrs. Caird and Co. have contracted to build for the North German Lloyd two large screws of 300ft. in length, with engines of 350-horse power. Messrs. M'Nab and Co have also contracted to build a screw of 1,200 tons for a Liverpool firm.

Steamship-Building Contracts.—Messrs. Caird and Co. have completed negotiations for a contract to build and engine two large steam liners for the North German Lloyd's, for the trade between Bremen and Baltimore. The ships will be about 2,300 tons and 350 h.p. These make in all 17 steam-ships constructed for this company by the same builders, who have likewise built 14 steamers for the Hamburg American Company. Messrs. M'Nab & Co. have contracted with a Liverpool firm to build a screw steamer of 1,200 tons. She will be fitted with compound high and low pressure engines.

## STEAM SHIPPING.

The S.S. "City of Limerick."—This vessel, belonging to the London, Belgium, and River Plate Royal Mail Steamship Company, has been just remodelled, her hull lengthened thirty two feet amidships, and her machinery and boilers overhauled and regulated according to the most approved system, by the enterprising shipbuilders Messrs Walpole, Webb, and Bewley, Dublin.

Quick Passage from Australia.—The celebrated steam ship *Great Britain* arrived in the Mersey on December the 5th from Melbourne, having accomplished the passage from port to port in fifty-three days. This is the fastest run ever made.

## LAUNCHES.

Some very interesting important trials with an improved steam launch, built and fitted with machinery specially intended to remedy a very serious defect existing in all such boats hitherto supplied to the ships of Her Majesty's navy have just been concluded at Portsmouth, under the superintendence of the officials of the Steam Reserve and Factory, and reported upon, for the information of the Controller's Department and the Board at Whitehall. The objectionable feature in the steam launches now attached to Her Majesty's ships is, the noise made by the exhaust steam, which can be heard at a considerable distance from the boat, and which renders them unfit for the most important of all the duties they could be called upon to perform upon an enemy's coasts in time of war; for instance, in cutting out or reconnoitring expeditions. The new steam launch which has just been subjected to these experimental trials at Portsmouth has been designed and built, both hull and engines, by John Samuel White, of East Cowes, Isle of Wight, who has already built and supplied to the Royal Navy, to Admiralty order, a number of steam launches and cutters constructed on his lifeboat principle. The main object kept in view in the design of the new boat has been to render her machinery as noiseless as possible when under steam; and, secondly, to obtain such accommodation for officers and crew and storage of fuel, water, &c., in a boat only 35ft. long and 9ft. beam, as to make her available for any service entailing a lengthened absence from the ship to which she might be attached. The depth of the boat is 4ft. 4in. She is decked over from forward to the stern-sheets, where there is open sitting-room for half-a-dozen people, in addition to the helmsman. From this there is an entrance to the main cabin, under the deck, which is 6ft. long, fitted with two good sofas available as sleeping berths at the sides, tables, and washstands on falling brackets, and ample store-lockers under the sofas and round the sides for provisions, &c. Next this cabin is a good-sized steward's pantry and watercloset. Forward of these is the engine and boiler-room, with coal bunkers, &c. The engines drive a single screw, the cylinders having a diameter of 6¼in, with a 6in, length of stroke, nominal power being 3-horse. The coal bunkers stow 15cwt. of coal, or sufficient for three days' consumption under full steam. Forward of the engine-room and of all is the forecastle, which gives ample accommodation for two or three men, with cooking galley, &c. A couple of masts carry fore and aft sails, and with all her weight and crew on board the boat's draught of water is 2ft. 6in. aft, and 2ft. 2in. forward. The mean speed of the boat is 7½ knots. The trials made with the boat at Portsmouth were considered by the officers conducting them as having been most satisfactory, the machinery of the boat having made scarcely any perceptible noise when driven at its highest speed, with no priming in the funnel, and with a perfectly equal draught in the furnace. The official report of the trials contains a recommendation that all steam pinnaces, launches, or cutters in future supplied to the navy should be fitted on the same noiseless principle as the boat sent for trial by Mr. White. In making this great improvement in rendering boats' machinery all but noiseless in its action, Mr. White makes use of one of the four copper side compartments with which the boat is fitted as a steam chamber into which he carries the exhaust steam from the cylinders, and whence, it is conveyed by a pipe into the smokebox. A perforated diaphragm strengthens this chamber and separates the steam. The boats fitted with steam machinery, and supplied to Her Majesty's ships, have, on an average, the following dimensions:—Steam launches of the old or general description—length, 42ft.; breadth, 11ft. 6in.; depth, 3ft. 9in. White's lifeboat steam pinnaces—length, 37ft.; breadth, 8ft.; depth, 4ft. 2in. White's lifeboat steam cutters—length, 23ft. 5in.; breadth, 7ft. 2in.; depth, 3ft. 2in.

On Wednesday December 2nd the first armour-plated war vessel built on the Tyne for the Government, the *Cerberus*, was launched from the building-yard of Messrs. Palmer and Co., Jarrow. She is intended for the colonies, and was designed by Mr. Reed, the Chief Constructor of the Navy.

Messrs. Schlesinger, Davis and Co., recently successfully launched from their iron shipbuilding-yard at Walls end, near Newcastle-on-Tyne, a screw steamer, intended for the cattle trade between Sweden and London. She is fitted with a hurricane deck, capable of stowing 150 head of cattle, with all requisite appliances for feeding, watering &c., combined with perfect ventilation. She also has accommodation for 50 passengers. The dimensions are:—209ft. in length, 28ft. 6in. in breadth, and 16ft. 2in. depth of hold. She is engined with two 40in. cylinders, surface condensing engines, equal to 100 nominal horse-power, by Thompson, Boyd, and Co., of Newcastle. This vessel has been built under Lloyd's special survey for A over B 1 classification. The steamer was named the *Prins Oscar*.

Shipbuilding in Italy.—At Leghorn the iron steamer *Messina*, belonging to Messrs. Danovaro and Co., has been lengthened 50ft. in the yards of Messrs. Oriondo, and she was launched a few days ago. The same builders are constructing a plated vessel (the *Coppellna*) for the Italian Government.

## TELEGRAPHIC ENGINEERING.

There are in the United Kingdom 90,668 miles of telegraph wire for public use, and 4,969 miles of wire used for the purposes of railway companies only. The number of miles of posts and underground lines constructed is 21,751 open to the public, and 285 used for railway purposes only; the average number of wires per mile is 4·16. There are 4,695 miles of submarine telegraph cables (of course including the Atlantic cables) connected with places in the United Kingdom, and 8146 miles of wire; the average number of these wires per mile is 1.73. There are 3,381 telegraph stations open to the public.

## RAILWAYS.

**The Southern Railway Company of Italy** has just bought a mansion at Brindisi, which is to be converted into a magnificent hotel for the accommodation of travellers. The company has also resolved to establish a line of steamers between Brindisi and Bombay, by which the passage will occupy twenty days, or four less than by Marseilles, at a saving of about £12 per head for each passenger.

**The Duke of Sutherland** has decided to extend the Sutherland Railway from Golspie to Helmsdale at his own expense. The distance is eighteen miles, and the cost cannot be much under £100,000.

**An** important series of experiments were made a short time ago on the North Eastern Railway system, with a view of testing various methods of communication between passengers, guards, and drivers, which have been devised in view of the adoption of one general system in April next, when a provision of the kind becomes compulsory on railway companies. The results of the observations will lead to a conference with the different managers, and form the basis of a suggestion to the Board of Trade for a uniform system of signalling in passenger trains.

**The** total number of passengers carried in 1867 by the British railways was 287,688,113, of which 187,262,108 were third-class and Parliamentary, 77,700,297 second-class, and 31,725,708 first-class. Loss of life occurred to 209 persons, and injuries to 795 others, being a slight decrease in the deaths, but an increase of 161 in the injuries over those of the year 1866. Only a small proportion of the entire number of deaths, namely 19, relate to passengers from accidents to trains, though 689 are returned as injured from this cause. Seventeen deaths of passengers are reported from carelessness in last year and no less than ninety fatalities to the companies' servants from similar negligence or indiscretion. Fifty-one deaths also arose from persons trespassing on the lines of rails, and six from suicides.

**The** *New York Tribune* states that the Emperor of Russia has sent two civil engineers to the United States, who are to examine the operation of Pacific and other great railways in that country. "The Emperor," the *Tribune* adds, "contemplates building a railroad from China, across Asia, to the capital of Russia, his purpose being to prevent the United States, with its railroads and steamships, from monopolising the whole China trade."

**The Hammersmith and Richmond Railway.**—The new line of railway from Hammersmith to Richmond, connecting the metropolitan system with the various suburban lines of the South-Western, was opened for public traffic on the 1st of this month.

**The Waterloo Junction Station on the Charing-cross Line.**—This commodious station has just been opened for the reception of the South-Western traffic. The booking-office and waiting-rooms for the general public are, as at the Blackfriars station, on the ground level, under the platforms. Although as commodious as the offices and rooms at Blackfriars station, they are more compact and comfortable, and, on the whole, better contrived as regards plan, and of superior finish in detail. The platforms, and especially their roofs, are a decided improvement upon the Blackfriars station. The platform on the north side of the station is 532ft. long by 18ft. width; 204ft. of this length is covered for the full width of the platform. The central platform, which will be available for trains in each direction is 435ft. long and 18ft. wide, of which 200ft. is covered from edge to edge. Both of these stages are upon the viaduct, which has been widened for the northern platform. The southern platform, for the use of the South-Western passengers, extends from the junction of the curved single line which unites the Charing-cross line and the South-Western system to the end of the Waterloo platform. This junction will not be used for ordinary passenger traffic, but for the Royal Family, for troop trains, through goods, horse-boxes, invalids, and other special purposes. This platform is 337ft. long and 15ft. wide, and under cover the entire length. A booking-office is provided on the platform for the convenience of the South-Western passengers. At the junction end there is an inclined plane, which leads to a subway under the line by which passengers will reach the platform stairs, and obtain access to the trains, which will stop to pick up passengers for Charing-cross, Cannon-street, or other stations of the South-Eastern system, and interchange traffic with the South-Western.

**Railways in Hungary.**—A Hungarian railway company, for which the concession has been granted to Waring Brothers, is shortly to be introduced in Paris and Vienna, with a capital of £3,000,000.

**A Concession** of a new group of lines, to be known as the Western of Hungary has been granted by the Hungarian Government to a *consortium*, or coterie of capitalists, comprising the Hungarian Credit Mobilier, the Duke of Modena, Prince Bathyani, and Count St. Ertody, with whom are associated Herr Weikerscheim, a contractor.

**It** appears from a parliamentary return that the railway companies of the United Kingdom hold more than 289 square miles land;—213·2 in England and Wales, 38·5 in Scotland, and thirty-eight in Ireland. The quantity is one acre of every 273 in England and Wales, one of 813 in Scotland, one of every 853 in Ireland; or taking the United Kingdom as a whole, one of 421 acres. The total is equal to 12.32 acres per lineal mile of railway, or an average width of land of 102ft. for every railway.

## DOCKS, HARBOURS, BRIDGES.

**Progress of the Suez Canal.**—From the 15th of October to the 15th of November 2,090,000 cubic metres were excavated; about 17,000 men are now employed upon the undertaking, and sixty dredging machines are engaged night and day. Of the 65,000,000 cubic metres which had at first to be excavated only 20,000,000 remain, so that there is less than ten months of work now to be done.

## MINES, METALLURGY, &c.

**Coal in Japan.**—Japan furnishes coal in abundance for the supply of the large fleet of steamers now possessed by the Japanese; and coal is exported in large quantities to Shanghae, where it finds a ready sale when English coal cannot be obtained.

**The** consumption of coal in Italy at the present time is estimated at upwards of eight millions of tons per annum, of the value of 360,000,000 francs (£14,400,000) the average cost per ton being 45 francs.

**According** to the last accounts from the Pennsylvania oil regions a discovery had been made of a regular oil-bearing stratum, at a depth not previously reached—an especially opportune circumstance, since during the present year there has been a great revival in the demand, with a gradually diminishing supply from most of the old sources.

## APPLIED CHEMISTRY.

**Aluminium Bronze.**—At the meeting of the Academy of Sciences at Paris on the 30th of November, the Count of St. Cricq-Cazeaux proposed to cover the worn-out steps of the column in the Place Vendome with thin sheets of aluminium bronze. M. Dumas approved of the idea, and reminded the meeting how successfully this bronze was now being used in various kinds of mechanism, especially in saws driven by steam power which saws, although much thinner, lasted a much longer time than those of steel.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| **COPPER.** | | | | | | |
| Best selected, per ton | 78 | 10 | 0 | 77 | 10 | 0 |
| Tough cake and tile do. | 77 | 10 | 0 | 78 | 0 | 0 |
| Sheathing and sheets do. | 81 | 10 | 0 | ,, | ,, | ,, |
| Bolts do. | 81 | 10 | 0 | 82 | 10 | 0 |
| Bottoms do. | 84 | 0 | 0 | 86 | 0 | 0 |
| Old (exchange) do. | 67 | 10 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** | | | | | | |
| Sheets, per lb. | 0 | 0 | 8½ | 0 | 0 | 9 |
| Wire do. | 0 | 0 | 8 | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11 |
| Yellow metal sheath do. | 0 | 0 | 7¼ | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 7 | ,, | ,, | ,, |
| **SPELTER.** | | | | | | |
| Foreign on the spot, per ton | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. to arrive | 20 | 10 | 0 | 20 | 12 | 6 |
| **ZINC.** | | | | | | |
| In sheets, per ton | 25 | 0 | 0 | 26 | 0 | 0 |
| **TIN.** | | | | | | |
| English blocks, per ton | 110 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 111 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 114 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 108 | 10 | 0 | ,, | ,, | ,, |
| Straits do. | 108 | 0 | 0 | 108 | 10 | 0 |
| **TIN PLATES.*** | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 5 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 11 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 2 | 6 | 1 | 3 | 0 |
| IX. do. do | 1 | 8 | 6 | 1 | 9 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| **IRON.** | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 12 | 6 | 6 | 15 | 0 |
| Do. to arrive do. | 6 | 10 | 0 | 6 | 12 | 6 |
| Nail rods do. | 7 | 0 | 0 | 7 | 2 | 6 |
| Stafford in London do. | 7 | 12 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 2 | 6 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 14 | 0 | 2 | 19 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| **STEEL.** | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| **LEAD.** | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 5 | 0 | 19 | 7 | 6 |
| Do. W.B. do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 0 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 22 | 10 | 6 |
| Spanish do. | 18 | 5 | 0 | 18 | 7 | 0 |

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* At the works 1s. to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

### DATED NOVEMBER 17th, 1868.

3488 J. Jones and S. P. Bidder—Apparatus for breaking down coal, &c.
3489 H. A. Bonneville—Instrument for prognosticating the weather
3490 R. Green—Means of covering telegraph wires employed under water
3491 G. H. Wilson—Securing or fastening window sashes
3492 G. Marquis of Montrichard—Machinery for transmitting motion, &c.
3493 J. E. H. Harris and T. Lumley—Chimney pots
3494 L. M. Prewitt—Stays or bodices
3495 W. R. Lake—Improved bayonet
3496 W. Mansfield—Kilns and drying chambers
3497 A. Clark—Machine for making ginger, &c.
3498 H. A. Kehde—Apparatus for working railway signals, &c.
3499 C. Richardson—Looms

### DATED NOVEMBER 18th, 1868.

3500 J. M. Pritchard—Fountain penholder.
3501 C. W. Siemens—Fastening telegraphic line wires
3502 W. P. Nash—Postal boxes
3503 C. E. Brooman—Composition for oiling or greasing wool
3504 F. O. Ward, W. Ibotson, and A. G. Southby—Drying down alkaline solutions
3505 M. Wilkin and J. Glark—Improvements in mining
3506 A. McDougall—Phosphatic manures, &c.
3507 A. W. Draveon—Cooling wort, &c.
3508 B. Bell—Affixing sheathing to iron ships
3509 W. L. Groundwatee—Percussion caps of cartridges, &c.
3510 W. T. Bassett—Washing sheep and other animals

### DATED NOVEMBER 19th, 1868.

3511 H. D. Hoskold and G. P. Wheeler—Artificial fuel
3512 G. V Fosbery, V C.—Breech loading firearms, &c,
3513 S. Crichton and J. Taft—Apparatus for grinding cards, &c.
3514 W. Thompson—Packing bottles
3515 C. D Abel—Manufacture of amorphous phosphate, &c.
3516 H. Carrigg—Manufacture of tribastic phosphate of lime
3517 W. Avery and A. Fenton—Needle cases
3518 T G. Webb—Tumblers, &c.
3519 D. Jones and J. Jackson—Imparting heat to the feet, &c.
3520 J. McGrath—Shirts
3521 J. Green—Rope, &c.

### DATED NOVEMBER 20th, 1868

3522 E. H. Bailey—Improvement in carts for the removal of snow, &c.
3523 J. McGlashan—Untwisting ropes
3554 J. D. Hopkins—Window sashes,
3525 D. Burns—chemical compounds
3526 A. Guthrie—Ploughs
3527 A. Leykauf—colouring matter
3528 B. Britten—Fishing rods
3529 F. D. Sutherland—Cravat holder
3530 W. Brookes—Fabric in lace machinery
3531 H. B. Cowell—Apparatus for distribution of water, &c.
3532 W. R. Lake—Reciprocating saws
3533 G. Egnilon—Suspending bells
3534 C. Descat and H. Guillaume—Fixing colours on textile fabrics
3535 A. V. Newton—Sewing needles

### DATED NOVEMBER 21st, 1868.

3536 W. R. Lake—Baling chopped hay, &c.
3537 J. G. Tongue—Yarns for weaving, &c.
3538 J. Scholes and J. Leach—Wool to carding engines, &c.
3539 C. D. Abel—Tobacco pouch and cigarette former
3540 C. Smith and J. Macfarlane—Washing machines
3541 C. E. Brooman—Gas for lighting and heating
3542 J. Sims—Ornaments to woven fabrics
3543 I. B. Harris—Driving bands
3544 C. J. Foster—Transverse reciprocating motions of the cutting bar in reaping, &c.

### DATED NOVEMBER 23rd, 1868.

3545 F. W. Webb—Steam hammers
3546 W. Inglis—Steam engines
3547 J. Mangnall—Chairs, &c.
3548 J. Bowden, M. N. Mills, and B. R. Mills—Carding engines
3549 W. La Penotiere—Construction of lock
3550 I. Hudson—Improved condenser for steam engine
3551 E. T. Hughes—Improvements in presses for compressing
3552 J. Howilson—Sleeping berths for railway carriages
3554 C. Crabtree and J. Still—Paper tubes
3554 B. Newnham and B. T. Newnham—Steps to carriages
3555 W. H. Ibbett—Apparatus for inducing motion in mobile substances
3556 W. A. Lyttle—Improvements in electro telegraphic apparatus
3557 J. Sturrock—Metallic caps
3558 C. Montagu—Pianofortes, &c.
3559 A. V. Newton—Dressing millstones
3560 W. E. Newton—Improvements in the manufacture of felted fabrics
3561 J. R. Swann—Improvements in burning lime
3562 T. Smith, M.D., and J. Van N. Bazalgette—Manufacturing manures from sewage and other foul waters
3563 W. H. Dreaper—Construction of pianoforte hammers
3564 J. E. Phillips—Sewing machines
3565 C. D. Abel—Converting cast iron into wrought iron &c.

### DATED NOVEMBER 24th, 1868.

3566 T. Culpin—Reaping machines
3567 J. H. Johnson—Safety tackle for raising and lowering heavy weights
3568 W. G. Beattie—Slide valves
3569 C W. Siemens—Improvements in the manufacture of iron, steel, &c.
3570 W. Carter—Apparatus for communicating in railway trains
3571 T. Prideaux—Sea walls
3572 W. Dinwoodie—Fences
3573 H. E. Newton—Atmospheric hammers
3574 H. E. Newton—Multiplying motion
3575 E. R. Wethered—Signalling in railway trains
3576 B. Solomons—Indicators

### DATED NOVEMBER 25th, 1868.

3577 B. Hunt—Watches
3578 J. Parry—Springs
3579 R. Lakin and W. H. Rhodes—Machines for spinning
3580 W. Wild—Mechanism to the driving shafts
3581 G. Bernhardt—Gas in mills
3582 T. Craig—Hanging windows
3583 P. Spencer—Indigo blue
3584 W. R. Lake—Cigars
3585 S. Brook and C. Thompson—Looms
3586 D. S. Merry—Arm protectors
3587 W. F. Chapman—Packing boxes
3588 G. Baker—Bird cages
3589 W. E. Gedge—Tug boat
3590 W. E. Gedge—Sewing machines
3591 H. Smith—Apparatus to be used in playing games
3592 E. T. Dan Hecke—Steam boilers
3593 N. D. Spartali—Heat to boilers
3594 J. Bourne—Production of heat, &c.
3595 H. Milsted—Buckle
3596 W. R. Lake—Sad irons
3597 D. Vogl—Fastening scarfs
3598 E. Ellenband—Threading needles

### DATED NOVEMBER 26th, 1868.

3599 L. Roman—Hydraulic power
3600 F. Holt—Steam engines
3601 P. Panton—Fire arms
3602 A. M. Clark—Sizing threads
3603 J. Sincock—Ratchet braces
3604 H Swithenbank—Hats
3605 C E. Spooner and G. A. Huddart—Construction of railways
3606 A. Busche—Laces
3607 E. T. Hughes—Dressing stones, &c.
3608 H. Pollock—Fire arms
3609 W. R. Lake—Paddle wheels
3610 W. R. Lake—Harvesting machines
3611 J. H. Moreland and J. Coulong—Pneumatic looms
3612 A. Harris—Warming churches, &c.

### DATED NOVEMBER 27th, 1868.

3613 E. Stevens—Sharpening knives
3614 J. S. Templeton—Carpets
3615 A. C. Bamlett—Machinery for Reaping
3616 T. G Webb—Tumblers, &c.
3617 J. Petrie, jun.—Dying wool
3618 T. Dickins A. L. Dickins, and H. Heywood—Dyeing silk
3619 W. E. Newton—Oil cups
3720 J. H. Dales and J. F. Maygrove—Looms for weaving hair cloth
3621 A. M. Clark—Paper clips

### DATED NOVEMBER 28th, 1868.

3622 W. Tranter—Breech loading firearms
3623 J Ingham and I. Butterfield—Warps
3624 E. S. Samuell—Manufacture of superphosphate lime
3625 A. Wyllie and J. Latham—Cracking palm and other nuts
3626 H. J. H King—Guages
3627 J. Cornes—Mowing grass, &c.
3628 A. N. Burton—Fastening shoes
2629 W. E. Gedge—A perspectometer
3630 W. E. Gedge—An improved plate warming apparatus
3631 C. D. Abel—Steel
3632 J. Saward—Means of preserving natural flowers &c.
3633 J L. Norton—Dyeing
3634 J. Heaton—Cast iron
3635 W. Naylor—Railway breaks, &c.
3636 G. S. Brown and E. Turner—Communicating between passengers, guard, and driver of a railway train, &c.

### DATED NOVEMBER 30th, 1868.

3637 W. Soaper—Breech loading firearms
3638 L. Pfeifer—Lock for bags
3639 J. S Forbes—Pottery
3640 T. Hill—Organs
3641 R. A. Green—Ornamenting plate, &c.
3642 A. M. Clark—Tiles
3643 D. Greig and I. Firnie—Plough heads, &c.
3644 N. West and R. G. West—Preservation of rudder pins, &c.
3645 J. Myers and L. L. Morrison—Hats
3646 W. McLellan—Improved fastenings for the rails of railways, &c.
3647 J. W. Reid—Bleaching vegetable fibre
3648 W. E. Newton—Cleaning cotton
3649 A. V. Newton—Mail bags
3650 A. Ransome—Circular saw benches
3651 J. H Johnson—Imitations of, and substances for wood, &c.

### DATED DECEMBER 1st, 1868.

3652 H A. Bonneville—Mineral teeth
3653 W. Bett—Capsules
3654 W. Brookes—Fabric
3655 J. B. Shilcock—Contents of bottles, &c.
3656 S. A. Daniell—Cleaning bottles
3657 E Price—Shirt front and collar
3658 J. H. Johnson—Carding engines
3659 W. H. Fuller and J. W. Barnum—Tuck markers
3660 J. Grindrod—Screw ships &c.

### DATED DECEMBER 2nd, 1868.

3661 C. S. Rostaing—Telegraph cables
3662 P. Ellis—Letter receptacle
3663 P. Ellis—Public conveyance
3664 J. Tidmarsh—Clipping horses
3665 T. Warburton—Piecing cardings of cotton or wool
3666 E. Hely—Envelopes
3667 J. Alexander and J. Hill—Signalling on railways
3668 H. N Maynard—Girders for bridges, &c.
3669 S. C. Lister—Weaving velvets
3670 S. Pallant—Fastening to stays, &c.
3671 T. B. Hubbell—Reflectors
3672 P. Hooker—Brick making
3673 A. M. Clark—Paving blocks, &c.
3674 E. W. P. Taunton—Chairs

### DATED DECEMBER 3rd, 1868.

3675 D. Dorrity—Locking printers' formes, &c.
3676 L. J. Marechal—Safety lock
3677 H. W. Grylls—Applying motive power
3678 W. Pugh and J. Field—Cataract lenses for defective visions
3679 W. E. Gedge—Ploughs
3680 J. H. Banks—Constructing buildings, &c.
3681 J. Littler and J. H. Banks—Furnaces
3682 C. H. Chadburn—Sketching
3683 R. Hornsby and J. E. Phillips—Reaping machines
3684 H. Kinsey—Boiler
3685 W. Simpson and J. Hutton—Lubricating apparatus

### DATED DECEMBER 4th, 1868

3686 W. R. Lake—Knitting machines
3687 W R. Lake—Cutting edible roots
3688 H. Robinson—Dressing millstones
3689 S. Hirsch—Dyeing yarns, &c.
3690 R. Charles—Thimbles
3691 J H. Johnson—Vapour apparatus
3692 J. G. Rollins—Nozzles for oil cans
3693 W. G. Ainslie—Drying peat, &c.
3694 M P. W. Boulton and J. Imray—Propellers
3695 H. L. D. Marsden—Toning photographic prints, &c.
3696 J S. Capelle—Calendar to desks
3697 F. Beech—Gullies
3698 A. C. Sterry, F Lambe, and J. Fordred—Purifying paraffine
3699 J. R. Swann—Kilns

### DATED DECEMBER 5th, 1868.

3700 E. Francillon—Dying fur
3701 J. A. Fawcett—Supplying steam boiler with fuel
3702 B. Hunt—Wheels
3703 D. Thomson—Sewing machinery
3704 R. Girdwood—Crushing ores, &c.
3705 H. Denton—Chain barrows
3706 E. K. Dutton—Gig mills
3707 A. V. Newton—Treating flour
3708 A. Masson—Steam engines
3709 J. Abraham—Central fire cartridges
3710 J. Holmes—Kilns
3711 B. Fowler, D. Greig, and R. Burton—Steam cultivating machinery
3712 D. H. Paterson—Bleaching, &c.
3713 W. R. Lake—Apparatus for removing the stem of metal formed upon printers' type
3714 A. M. Clark—Compound for the disinfection of sewage

### DATED DECEMBER 7th, 1868.

3715 A. B. Berard—Purifying gas for heating and other purposes
3716 I. E. Woolf—Cooling milk
3717 W. Chiswell—Preventing horses from slipping in snowey weather, &c.
3718 A. Homfray—Coke
3719 J. Ridley—Apparatus for obtaining motive power
3720 A. Krupp—Breech loading ordnance
3721 E. Simons—Shoes for horses
3722 W. R. Lake—Photographing by artificial light
3723 Railway carriage wheels
3724 C. F. C. Cretin and J. Watson—Supplying air to divers
3725 T. Kennan—Fastenings
3726 A. M. Clark—Thread winders

### DATED DECEMBER 8th, 1868.

3727 C. Farrar—Reducing wood to fibers, &c.
3728 A. Mackie—Type composing apparatus
3729 H. A. Bonneville—Spinning looms
3730 W. J. Thiethiuer—Chronometers
3731 J. A. Farwig and C. Haynes—Sheet metal casks
3732 J. Fitter—Nuts or screw boxes
3733 O. Reynolds—Communicating between passengers guard, and driver of railway trains
3734 R. B. Roden—Breech loading firearms
3735 T. Speir—Machinery or apparatus for cultivating land
3736 T. Speir—Machinery or apparatus for cultivating land
3737 T. Lancaster—Consumption of fuel
3738 F. W. Moss and G. Moss—Preventing collisions on railways
3739 G. Cooper and J. Cotterill—Crucibles
3740 C. P. Cotton and J. L. Lyster—Kilns for calcining ores, &c.
3741 W. H Pottle—Umbrellas
3742 J. Kirk and J. Kirk—Weavings made on bobbin machines
3743 J. Ball—Cutting fibers from spots
3744 G. P. White—Roadways of bridges
3745 W. Baines—Working the switches on railways

### DATED DECEMBER 9th 1868.

3746 S. S. Anderson—Bricks
3747 J. T. Parlour—Adjustable blocks
3748 F. Meadows—Cutting brass rule
3749 R. Needham—Fuel economizers
3750 J. Bolton—Burning animal charcoal
3751 J. Parkins—Printing in colours
3752 T. Sturgeon—Communicating between the passengers, guard, and driver of railway trains
3753 A. G. Goodes—Cigars

### DATED DECEMBER 10th 1868.

3754 W. Griffiths—Bits and bridles
3755 J. Norman—Grinding grain
3756 W. H. Platt—Shuttles
3757 W. G. Mainwaring—Sewing machines
3758 A. Matthiesen—Manufacture of paper
3759 H A. Bonneville—Apparatus for measuring distances
3760 W. Gray and T. Biggin—Spanners in cast steel
3761 W. S. Jackson—Treating bones
3762 I. Smith and J. F. N. B. Simons—Setting steam boilers
3763 C. E Brooman—Roofing houses
3764 J. F. Bentley—Improvements in wells, &c.
3765 W. Dawes and E. A. Ramsden—Improvements in harmoniums

### DATED DECEMBER 11th, 1868.

3766 J. Pickles, E. Ramsbottom, S. Haggas, S. Foulds, J. Shackleton, and W. Berry—Spinning and twisting frames
3767 B. Waygood—Ventilation of mines
3768 T. Holder and G. Dover—Horseshoes
3769 H Carter and G. H. Edwards—Breech loading firearms
3770 P Kotzo—Reaping machines
3771 W. H Pailey—Apparatus for indicating and regulating heat
3772 F. Walton—Construction of houses

### DATED DECEMBER 12th, 1868.

3773 E H. Bayley—Filter vans and carts
3774 B. Hunt—Apparatus for cooking
3775 J. Millward—Preserving meat
3776 A. Woods—Spring matresses
3777 H. Law—Water closets
3778 C. Ellison and E. Parkinson—Apparatus for measuring the human body for garments
3779 T. Smith—Smiths' bellows
3780 Z. Poirier—Stopper for bottles
3781 S. Copperthwaite—Turning
3782 C. E. Brooman—Apparatus for indicating hours and days
3783 G Preston and J. Prestige—Engine lubricators
3784 F. Erskine—Economizing fuel and consuming smoke
3785 J. Hamilton and J. B. Crawford—Cutting and dressing stone, &c.
3786 A. Prince—Treatment of ores
3787 G. A. C. Bremme—Breaking and softening flax
3788 H. L. D. Marsden—Construction of framings and joints
3789 J. Hine—Cutting millstones

### DATED DECEMBER 14th, 1868.

3790 R. Norfolk—Reaping machines
3791 W. Meakin—Lock spindles
3792 H. E. Newton—Machinery for transmitting power and motion
3793 J. J. Stevens—Working railway switches
3794 S. W. Smith—Apparatus for spinning
3795 J. Allmark and W. Blakey—Tobacco cutting machine
3796 C. E. Brooman—Locks
3797 W. J. Murphy—Ordnance
3798 J. Thomas—Teakettle
3799 Lord J. Hay—Engine counters
3800 T. Lynch—Preventing collisions on railways

### DATED DECEMBER 15th, 1868.

3801 A. Watt—Rollers for printing purposes, etc.
3802 J. H. Brown—Helmets, etc.
3803 C. Mather—Machinery for ginning, etc.
3804 H. A. Bonneville—Production of motive power
3805 H. Williamson—Hats
3806 A. Baumann—Pressure governed slide valves
3807 R. S. Garden—Cartridge pouch
3808 W. Bywater—Manufacture of felt
3809 J. W. Chilcott—Stays
3810 C. A. B. Pocock—Bedsteads, etc.
3811 C. E. Brooman—Apparatus used in diving
3812 M. Lookhart—Ventilating
3813 M. Brown-Westhead and R Smith—Spools
3814 J. Frazer and W Naar—Mattresses
3815 P. Kotzo—Steam engines
3816 T. Wilson—Couplings for connecting tubes
3817 J. T. Grice—Ornamenting metallic tubes
3818 J. E. Scriven—Heating air in chambers, etc.

### DATED DECEMBER 16th, 1868.

3819 J. Mill—Heating press plates
3820 W. Cotton and E. Attenborough—Looped fabrics
3821 W. N. Nicholson—Portable mangles
3822 W. A. Verel and J. Cameron—Precipitation of copper, etc.
3823 J. Hollingworth—Open and closed carriage
3824 J. B. Everard—Boring rocks
3825 T. C. Fidler—Rolling stock of railways, etc.

S ,

FIG. I.

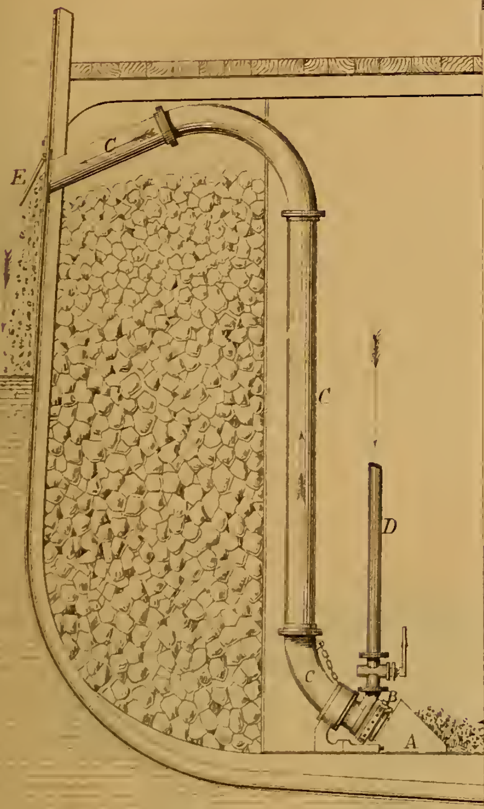
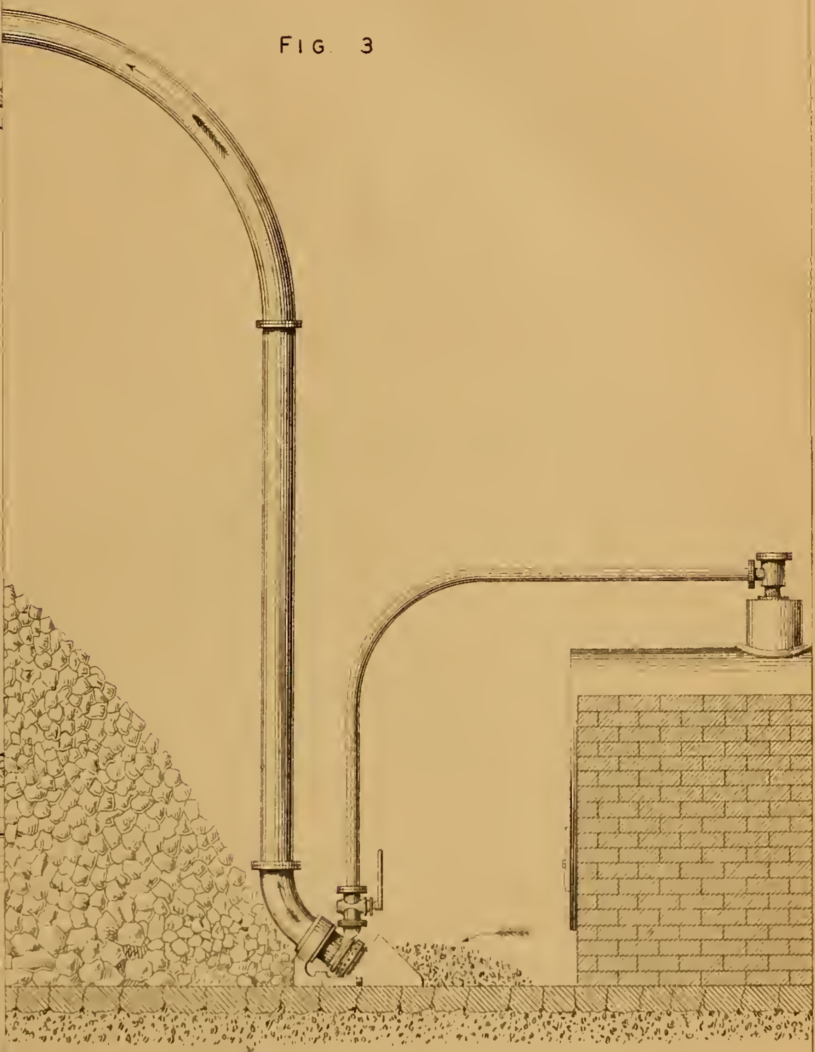


FIG. 3



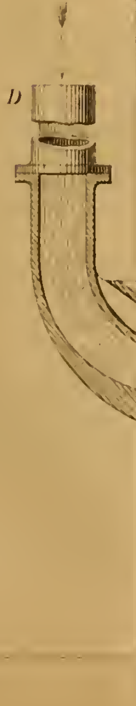
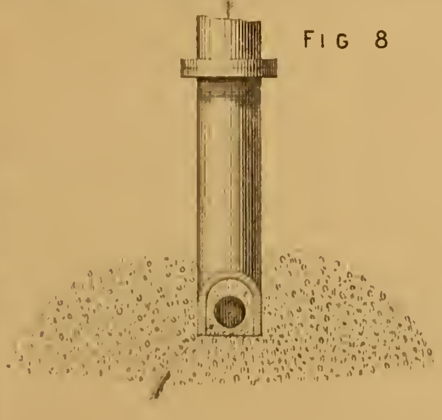


FIG 8



ith C E lnv.

# ROBERTSON'S EJECTOR FOR REMOVING SOLID MATERIALS.

FIG 1

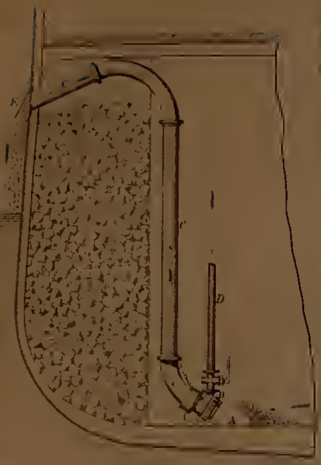


FIG 2

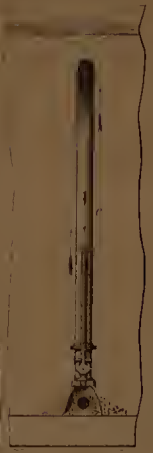


FIG 4

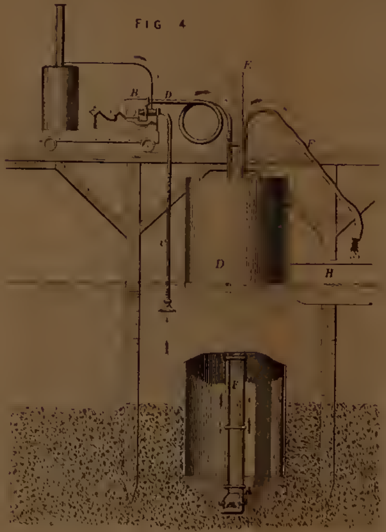


FIG 3

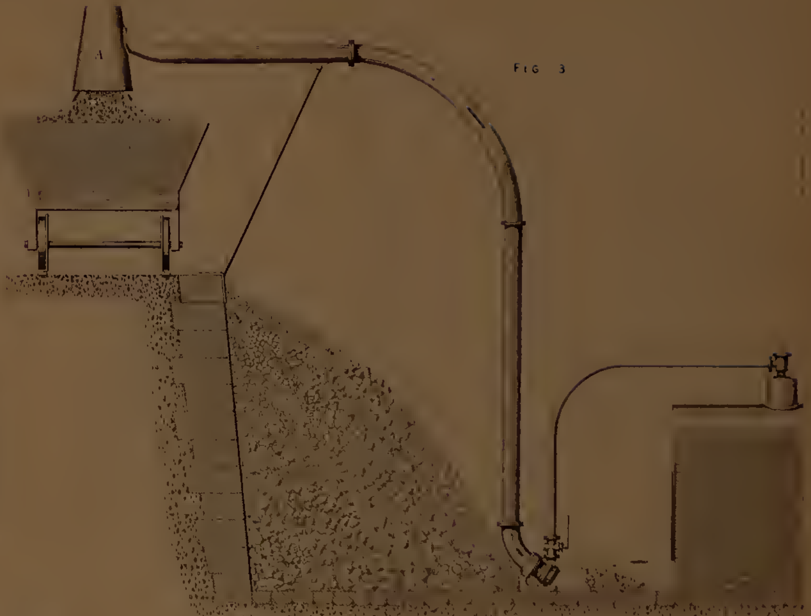


FIG 5

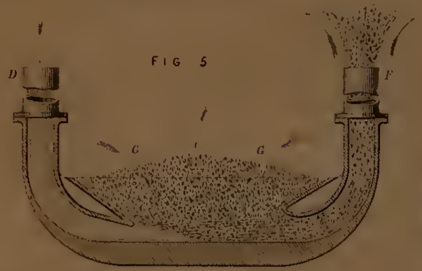


FIG 6

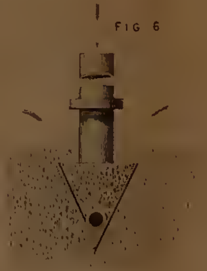


FIG 7

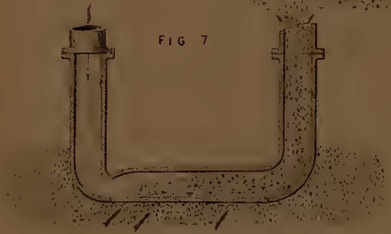
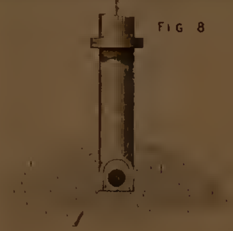


FIG 8



# THE ARTIZAN.

No. 2.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

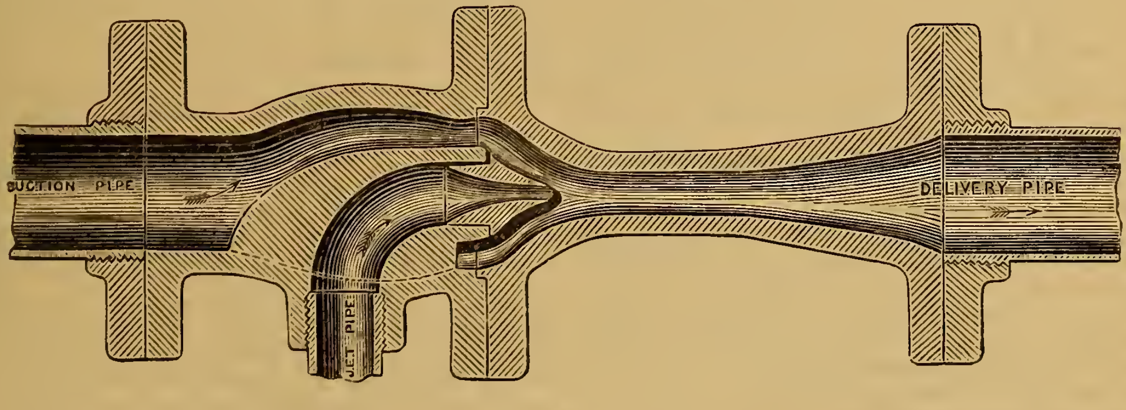
1st. FEBRUARY, 1869.

## JET EJECTORS AND EXCAVATORS.

By James Robertson, Glasgow.

(*Illustrated by Plate* 341.)

Since M. Giffard first introduced his well-known injector, the principle of which is even now but imperfectly understood, there have been numerous modifications and some improvements upon the original design; but until lately the object of all these various modifications were designed for the same purpose, viz.: that of forcing water into a boiler by means of its own steam. A short time ago the application of this principle was extended and applied to the purpose of raising water by means of a water jet supplied from a head of considerable height; this was reported upon very favourably by several engineers in France, in which country it was first adopted. It has since been tried in this country, and the annexed woodcut shows a section of the apparatus as applied by Mr. Reynolds in the works of Messrs. Vickers, of Sheffield. The water in this case is supplied to the jet from a head of 240ft., the jet being about ⅛in. diameter, and the throat into which it discharges about ¾in. diameter. The suction and delivery pipes are both 2in. diameter, and the pipe through which the water is led to the jet is 1in. diameter. This jet-pump draws water from a depth of 14ft., without any foot-valve to the suction-pipe. In order to facilitate the drawing of the water immediately it is put in action, the discharge pipe must not be quite straight, for in that case the jet is liable to pass merely through the centre. If it is formed with bends, or if the discharge is momentarily impeded by the hand, the pump will at once begin to draw. The efficiency of pumps of this description is said to be very great, amounting to about 72 per cent. of the power expended—a duty considerably greater than pumps of the kind usually employed.



In The Artizan for last month a beautiful modification of this principle was illustrated (Morton's ejector condenser, Plate 340), in which the exhaust steam from a pair of engines was made to supply the water intended for its own destruction. We now illustrate, by Plate 341, some of the useful and ingenious applications of inducing jets of air and steam combined, and of water-forcing jets, recently introduced by Mr. James Robertson, of Glasgow.

The ashes ejector represented by Figs. 1 and 2, is already extensively in use in merchant steamers, and, we understand, is about being introduced into the Royal Navy. The apparatus is of such a simple character, so efficient and well suited for the work it has to perform, that we have no doubt but that it will soon be regarded as a necessary part of the fittings of all steam vessels. The operation of lifting ashes out of the stoke-holes of steamers by buckets, and discharging them over the side of the ship, is well known to the passengers and officers of vessels as a great nuisance, by the ashes being blown about the decks; while the discharging of them by the ordinary means is about the heaviest and dirtiest of the somewhat rugged duty of the stokers.

Fig. 1 is a sectional elevation of the stoke-hole of a steamer, showing, in it, a side elevation of the apparatus, of which Fig. 2 shows a front elevation. The apparatus is shown placed on the stoke-hole floor, consisting of a mouth-piece A, and annular jet-piece B, to which is connected the ashpipes C C C shown led through the coal-bunker to the skin-plate of the vessel. The annular steam-jet is 6in. diameter, which is also the diameter of the ashes-pipe, the entrance for the ashes at the neck of the mouth-piece being somewhat less in diameter, to prevent too large pieces getting into the pipe. Steam is conveyed to the apparatus from the main boiler, a portion (D) of the steam-pipe being shown connected. The pressure of steam required may vary from 10lbs. on the square inch upwards, less of it being required at high pressure, for which the apparatus is made adjustable, the annular opening being set about $\frac{1}{32}$in. wide for steam at 25lb. pressure. The quantity of steam that passes up the pipe is very small, compared with the volume of air that it induces; and so strong is the current produced in this way, that the heaviest clinkers, stones, or even pieces of iron, may be freely taken up the pipe. The ashes are entered at the mouth-piece A, and discharged as indicated by the arrows. An iron hinged flap-valve E is fitted on the skin-plates of the vessel, to direct the current of the ashes down into the water, and also to prevent the water from getting into the pipe. To further secure water from getting into the stoke-hole when the vessel is rolling, a brass sluice-piece may be fitted on to the brass jet-piece B, so that, if the water should get in, it could only fill the ashes-pipe, and is forced out as soon as the steam is introduced. The quantity of steam used by the apparatus when in operation is about equal to that required by a 6-horse power engine; but as the action of the apparatus is very expeditious, the ashes formed in a watch of four hours being discharged in a few minutes, the steam used is quite inconsiderable. The disagreeable, but necessary, operation of extinguishing the heat in the ashes by water when they are to be lifted by buckets is, in this case, not required.

Fig. 3 is a side elevation of a similar apparatus, used for raising and discharging ashes into trucks or carts from deep-set stoke-holes of stationary boilers. To prevent the ashes and steam from being blown about, the discharge-end of the pipe has fitted on it a conical vessel (A) of sheet iron, and closed at the top. The current of the ashes and steam directed against the top plate of this vessel is thus made to expend its force; while the steam, being afterwards allowed to expand in the large area of the vessel, condenses or escapes without any pressure, slightly damping the ashes by its condensation.

Fig. 4 is an elevation of a jet-lifter or excavator, adapted for excavating sand under water, for the purpose of sinking cast iron foundation cylinders. The action in this instance is somewhat different from the applications just described, and is termed a forcing jet lifter. The method of using, and the mode of action, of this apparatus, will, perhaps, be best understood by first explaining the principle of action of the jet mouth-piece. This mouth-piece (A) is shown in Fig. 4 at the bottom end of the foundation cylinder, which is being forced down into the sand, and is also shown in section on an enlarged scale in Figs. 5 and 6, Fig. 5 being a side sectional elevation, and Fig. 6 an end elevation. This mouth-piece, it will be seen, is of a wedge form on its under-side, for sinking down in the sand by its own weight, with the addition of the weight rods and malleable iron pipes connected to it. The flow or current of water through the mouth-piece is indicated by the arrows seen in Fig. 5, the sand being induced into the centre of the current through the hopper-shaped opening formed in the top of the mouth-piece. For working this apparatus a centrifugal pump, driven by a portable engine, is mounted on the tram-rails usually erected for other necessary work for sinking foundations, &c., and which lifts water as indicated by the arrows (Fig. 4) through the pipe C, the discharge and forcing pipe (D) from the pump being in part made of flexible hose at the top. It is thence continued down to the mouth-piece A, and secured to the wooden rod E; the lifting-pipe (F F) from the discharge side of the mouth-piece (A) being also fixed to this rod, forms the pipes and mouth-piece into a stiff compact piece for being set down into the sand to any required depth. Thus arranged, on the pump being set in motion, water is drawn up through the pipe C, and forced down through the pipe D D, past the jet mouth-piece A. The sand falls through the hopper-shaped opening G G (seen in Figs. 5 and 6), and is forced, along with the water, from the pump up through the lifting pipe F F, into the barge H, or dropped into the water, as circumstances may require. As the cylinders are set down, additional lengths of rod are coupled on, for which the facilities are great.

It has been found that a ton of sand can be raised per minute in this way, through a pipe 4½in. diameter; the jet being 2½in. in diameter, and the pressure about 40lbs. per square inch.

Figs. 7 and 8 represent another form of mouth-piece, with the entrance opening of the mouthpiece on the under side, suited for harder descriptions of material than soft sand. The flow of the current is as indicated by the arrows, and its action is otherwise similar to that described in connection with Figs. 4, 5, and 6.

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## TRIAL OF H.M.S. "HERCULES."

This frigate, which forms such an important addition to the strength of our iron clad navy, has made her trial trip at the measured mile, and therefore a fair estimate can now be formed of some of her qualities. Although a description of the *Hercules* has already appeared in The Artizan, it may be as well, in order that her performances may be fairly estimated, to recapitulate some of her leading dimensions, which are as follows:—Length, 325ft.; breadth of beam, 59ft.; draught forward, 23ft.; do. aft., 26ft., 5in.; tonnage, 5,126; displacement at the time of trial, 8,680 tons; area of immersed section, 1,315 square feet. The machinery of the ship consists of a pair of Messrs. John Penn and Sons' trunk engines, of 1,200 nominal horse-power, stipulated to indicate six times their nominal power on the official measured mile trial. The diameter of the cylinders 127in., and the diameter of the trunks 47in.; effective diameter of cylinder, 118in.; length of stroke, 54in. Each cylinder weighs 32 tons 17 cwt. The cylinders are jacketed all over, and the covers are cast hollow. The cut-off is effected by gridiron expansion valves, travelling on faces on the upper sides of the slide valve boxes. The condensers are vertical cast-iron cylinders standing at the side of the crank shaft farthest from the steam cylinders. They are 11ft. 3in. in diameter and the length of their copper tubes measures in the aggregate 12 miles. The condensing water is driven through the tubes by two Appold centrifugal pumps, drawing water either from the bilge or sea, each capable of discharging 60 tons of water per minute, and worked by a pair of engines of 40 horse-power. There are two boiler rooms, each containing four boilers with their stockholes amidships. There are 40 furnaces in all, the size of the fire grates being 2ft. 10in. by 8ft.; number of tubes, 3,600. Length of tubes 7ft., and their outside diameter 2in. The crank shaft weighs 34 tons 16 cwt., and the screw shaft 24 tons. The total weight of machinery, boilers filled with water, and spare gear is estimated at 1,090 tons, or rather less than 2¼ cwt. per indicated horse-power. The screw, which is a two-bladed Griffith, has a diameter of 23ft. 6in., the pitch varying from 20ft. 6in. to 25ft. 6in., and having 1ft. 11½in. immersion of the top edge; it weighs 23½ tons. The safety valve is weighted to 30lb. per sq. in., and the steam is super-heated to about 310.

At the time of the trial, which lasted about five hours and a-half, the weather was very favourable, the barometer standing at 30·2in., with a smooth sea and very little wind. The pitch of the screw was set at 24ft. The ship made all her runs over the measured mile with her rudder acting in the ordinary way, and not as a balance rudder. The time of the ship throughout was taken with one of Benson's chronographs. The runs over the mile gave the subjoined results:—

Mile Runs with Full-Boiler Power.

| No. of run. | Time. M. | s. | Ship's speed. Knots. |
|---|---|---|---|
| 1 | 3 | 47 | 15·859 |
| 2 | 4 | 29 | 13·383 |
| 3 | 3 | 43 | 16·143 |
| 4 | 4 | 35 | 13·091 |
| 5 | 3 | 39 | 16·438 |
| 6 | 4 | 41 | 12·811 |

Steam pressure in boiler-room, 29·5lb.; at engines, 27lb.; Vacuum, 27in. Revolutions of Engines.—Per minute—72, 71, 72, 71, 72, 71; per mile—288, 318, 265, 230, 262, 335. Mean speed of the ship under full-boiler power, 14·691 knots per hour, indicated horse power, 8528·75.

Mile Runs with Half-Boiler Power.

| No. of run. | Time. M. | s. | Ship's speed. Knots. |
|---|---|---|---|
| 1 | 4 | 27 | 13·483 |
| 2 | 5 | 21 | 11·215 |
| 3 | 4 | 40 | 13·857 |
| 4 | 5 | 19 | 11·285 |

Mean speed of the ship under half-boiler power, 12·122 knots per hour, indicated horse-power, 4044·9.

Full-Boiler Power Circles, with Rudder in Balance Form.

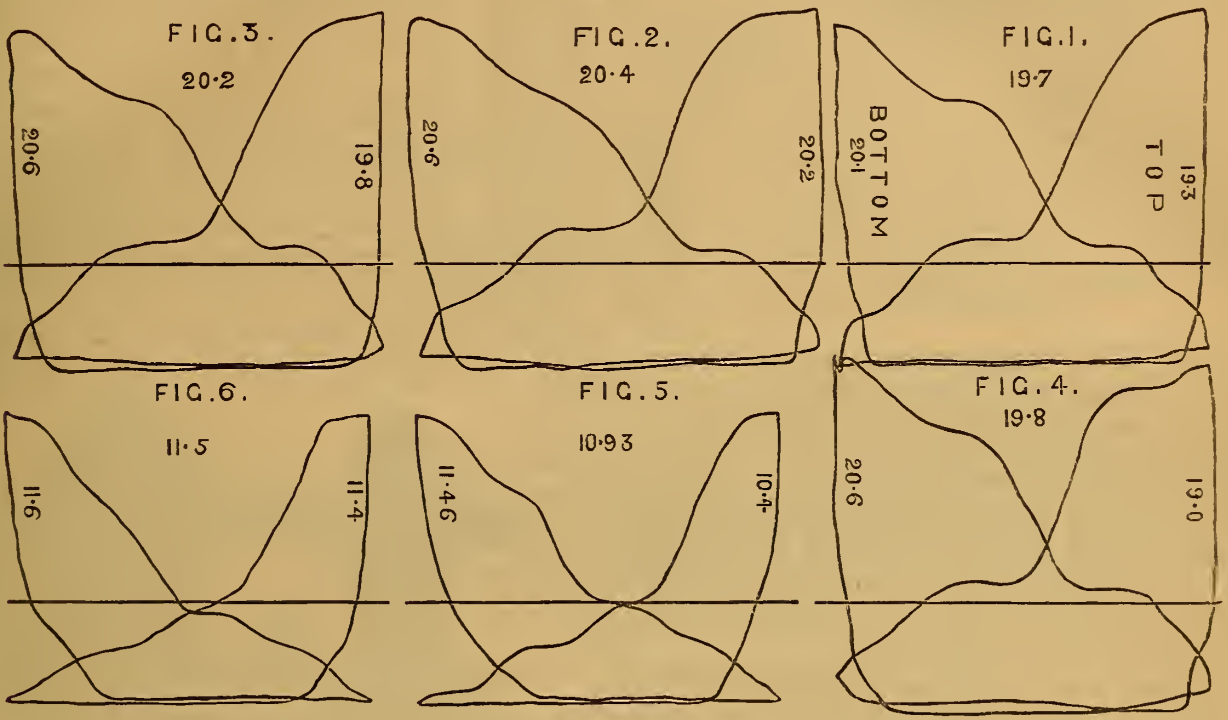
Helm to Starboard.—Angle of rudder, 40 deg.; turns of wheel, 4. Half-circle made in 1 min. 50 sec.; full ditto, 4 min. Men at the wheel, 16. Helm to port.—Angle of rudder, 38 deg.; turns of wheel, 4. Half-circle made in 1 min. 50 sec.; full ditto, 4 min. Men at the wheel, 16.

Half-boiler Power Circles, with Rudder in Balance Form.

Helm to Starboard.—Angle of rudder, 40 deg.; turns of wheel, 4. Half-circle made in 2 min. 21 sec.; full ditto, 4 min. 36 sec. Men at the wheel, 16. Helm to Port.—Angle of rudder, 39 deg.; turns of wheel, 4. Half-circle made in 2 min. 40 sec.; full ditto, 5 min. 20 sec. Men at the wheel, 16.

The diameter of the circles were very small. Those at full power were: — Starboard, 527yds.; port, 597yds.; at half-power starboard, 590yds., and port 651yds.

In the annexed set of diagrams, figs. 1 and 2 were taken from the after and forward engines respectively during the first mile run, and figs. 3 and 4 are similar diagrams taken during the sixth mile run, figs. 5 and 6 being taken while running with half boiler power.



An average speed of 14·691 knots at full-boiler power at first sight seems very good; but when it is remembered that it required the enormous propelling force of 8528·75 H.P. to obtain that speed the performance does not appear so satisfactory. According to this official trial, the co-efficient of the *Hercules* in the formula $\frac{\text{speed}^3 \times \text{displacement}^{\frac{2}{3}}}{\text{I.H.P.}}$ is only 156·7, while that of the *Bellerophon* is 164·7; of the *Minotaur*, 208; of the *Achilles*, 227·4, and of the *Warrior*, 231·5. From these figures it is evident that, so far as regards form, the latest addition to our iron-clad fleet is also the worst. As an illustration of the peculiarity in the bow lines of the vessel, the following graphic account given by the correspondent of the *Times* may not be out of place:—"A rather startling incident occurred at the time the ship was going at her greatest speed in running the fifth mile. A large decked boat, with two men in her, got directly in the path of the ship and ahead of her. The pilot sheered the huge frigate wide of her course, but the boat could not keep clear, and for a moment her mast was seen bobbing and swaying about immediately under the vessel's bowsprit. It seemed impossible on board the frigate to avoid going clean over the cockle-shell of a thing under the bows, but just as the boat's side appeared to touch the frigate's stem the huge wave raised up in front of the latter lifted up the boat and dashed her aside and clear of danger, although the gaff of her mainsail grazed the port bow of the frigate, as the latter rushed along at 17 miles an hour." The huge wave here mentioned may have been a very gratifying sight to these two men, but we doubt whether it would be similarly appreciated by a naval architect when contemplating its enormous dimensions from a less hazardous position.

As the *Hercules* is unable to carry coal sufficient for two days full steaming, she may be considered as more especially adapted for harbour and coast defence, for which purposes, from her immense strength, she is admirably suited. She carries no less than 1,480 tons of armour, while her armament weighs about 540 tons. The armour consists of a band of plating entirely round the ship from 5ft. below the water-line to 9ft above it, the thickness of the band graduating, but reaching its *maximum* thickness of 9 inches in the row of plates at the water-line. From this band rises the great central battery, and here the plating is disposed in eight tiers, which are thus arranged:—At the water-line one width of 9-inch plates, and next above this one width of 8-inch. Above the 8-inch are five rows of 6-inch, and then another width of 8-inch. The battery is closed at each end by 6-inch plated bulkheads. The weight of the ship's side and its armour at the water-line is, approximately, 795lbs. per square foot, and at the level of the gun deck 582lbs. per square foot.

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## ON THE ESTIMATION OF TITANIC ACID.

By David Forbes, F.R.S., &c.

The results of numerous analyses of rocks and of the products arising from their disintegration and decomposition have proved thoroughly confirmatory of the observations by Mr. Riley, brought forward in his valuable paper "On the General Occurrences of Titanic Acid in Clays, &c.," published in vol. xv. of "The Journal of the Chemical Society;" and having myself, in the course of these investigations, paid considerable attention to the various processes employed for determining the presence and amount of titanic acid contained in mineral and metallurgical products, it is considered that the following remarks upon this subject may probably be of use to the analyst:—

As it still appears to be the common opinion that, in the process of the analysis of mineral silicates, titanic acid when present does remain altogether, or in greatest part behind along with the silica, which has been separated from the bases, it seemed, therefore, desirable to ascertain how far this actually was the case, and also whether any definite ratio existed between the amount of the insoluble titanic acid which remained behind with the silica and that which was taken up by the acid solution.

The result of the examination of several clays and rocks containing this acid, served to show that a very considerable amount of the entire titanic acid present in the subject analysed did really enter into solution, and consequently that a material error would occur in the statement of the results of the analysis, if this amount was neglected, and merely the quantity remaining behind with the silica was assumed to represent the total percentage of titanic acid present in the substance under examination.

A single example will suffice to show that this is actually the case. Upon analysis, at the request of Mr. George Maw, F.G.S., of a red clay, which formed a stratum of from 7 to 8ft. in thickness, occurring at about the middle of the Shropshire coal measures at Calcotts, near Broseley, the following percentage composition was found :—

| | | |
|---|---|---|
| Silica, combined | 29·71 | 64.06 |
| „ free | 34·35 | |
| Titanic acid, insoluble | 0·37 | 0·62 |
| „ soluble | 0·25 | |
| Alumina | | 20·60 |
| Sesquioxide of iron | | 6.84 |
| Protoxide of iron | | 0·32 |
| Protoxide of manganese | | 0·09 |
| Lime | | 0·12 |
| Magnesia | | 0.04 |
| Potash | | 0·91 |
| Soda | | 0·44 |
| Water, with traces of organic matter | | 5·85 |
| | | 99·89 |

From these results it will be seen that above 40 per cent. of the entire amount of titanic acid present in the clay had entered into solution, and was afterwards thrown down by ammonia (which precipitates titanic acid completely) along with the alumina and sesquioxide of iron obtained together in the course of the analysis.

The method employed in separating the titanic acid from these substances, was simply to dissolve the precipitate of alumina, sesquioxide of iron, and titanic acid in dilute sulphuric acid, to neutralise a considerable portion of the excess of sulphuric acid by solution of caustic soda, then to add a few drops of nitric acid, which prevents the titanic acid subsequently precipitated from carrying down with it more than a trace of sesquioxide of iron, and after still further dilution with a large excess of water, to boil for some time until all the titanic acid is precipitated in the insoluble form.

The insoluble titanic acid remaining with the silica was extracted from it, by boiling the silica in a platinum crucible for some time, with concentrated pure sulphuric acid, allowing it to cool, and then pouring the whole rapidly into a large excess of cold water, so as to avoid any considerable rise in temperature of the solution; after filtration from the insoluble silica, the solution was nearly neutralised by soda, a little nitric acid added, and the titanic acid precipitated by boiling as before.

According to Marignac, titanic acid is precipitated from its solution in concentrated sulphuric acid after dilution with from five to six times its volume of water upon boiling; but it was found safest to neutralise a large portion of the excess of the acid by soda before boiling the solution, which, after filtration, was, upon subsequent testing, not found to retain any appreciable amount of titanic acid.

The results of various experiments, not only proved that the proportion of titanic acid dissolved, amounted to a very large percentage of the total titanic acid contained in the silicate, but also showed, especially when but very little titanic acid was present in the mineral or rock, that the amount which entered into solution might occasionally be much greater than that which remained behind with the silica. In all analyses, therefore, it becomes a matter of necessity to determine both the soluble as well as the insoluble titanic acid, in order to obtain correct results both as regards the amount of titanic acid present or also to obtain the true percentage of the silica, alumina, and sesquioxide of iron. Even when the total amount of titanic acid in a mineral has been determined by the usual process of fusing it with from eight to sixteen times its weight of bisulphate of potash, or, still better, bisulphate of soda (since the soda compounds are much more soluble), and afterwards boiling the very dilute solution of the fused mass in cold water, until all titanic acid is precipitated; there still remains the difficulty of knowing how much of the titanic acid thus found should be deducted respectively from the weight of the silica, or from that of the mixed precipitates of alumina with sesquioxide of iron.

In these cases I have found the following mode of procedure convenient:—The mineral, clay, or rock, reduced to an impalpable powder, is placed in a proper sized platinum crucible, and made into a very liquid paste with pure concentrated sulphuric acid; the whole is then kept for some hours exposed to a temperature sufficiently high to cause it to emit slight fumes of sulphuric acid without making it boil or spirt. By this means the entire amount of titanic acid present, combined or uncombined in the substance, appears to be converted into the soluble modification, and is taken up by the sulphuric acid.

The whole is now allowed to become quite cold, the contents of the crucible is then discharged into a beaker glass containing so large an excess of cold water that no rise of temperature need be apprehended, and the crucible itself washed out with cold water. This solution is now filtered from the insoluble matter, consisting of silica along with any undecomposed silicate which may remain unacted upon by the sulphuric (and if much lime, strontia, or barytes, is present, some sulphates of these earths) acid ; this should be washed, first with cold and then with hot water. The filtrate is now nearly neutralised by caustic soda, and boiled for a considerable time, occasionally adding some water as evaporation takes place, so as always to keep the solution very dilute until all the titanic acid has been precipitated.

Should much iron be contained in the solution, a little nitric acid should be added to the filtrate previous to boiling, in order to prevent the titanic acid carrying down with it more than a trace of sesquioxide of iron.

The titanic acid thus obtained usually retains some sulphuric acid, and should be heated with the addition of a little carbonate of ammonia to volatilise this acid. After ignition the titanic acid usually is of a light yellow colour, but should it present a deep red appearance, due to sesquioxide of iron carried down along with it, it should be fused with bisulphate of potash or soda, the fused mass dissolved in an excess of cold water, a few drops of nitric acid added, and the solution boiled, when is will be obtained nearly colourless, or of a faint yellow tinge.

The insoluble matter obtained after treatment of the original substance may now be fused with carbonate of soda and potash as usual in the analysis of an insoluble silicate, taking care, of course, to add to its solution the filtrate from which the titanic acid has been precipitated by boiling.

In some cases, where but traces of lime or other element which would form a sulphate insoluble in water, or solution of sulphate of soda or potash are present (zirconia thorina, &c.), the analysis may be made by fusing the mineral with about ten times its weight of bisulphate of soda, potash, (preferably the former, from the easy solubility of its fused product) dissolving the mass in cold water, and filtering it from the insoluble silica, which, after washing, first with cold and then with hot water, may be weighed after ignition, as usual. From the filtrate, the titanic acid is precipitated by boiling, some nitric acid having previously been added, in case oxide of iron is present in any quantity, and after filtration the solution can be used for determining the bases, alumina, iron, magnesia, &c., as usual.

In estimating the amount of titanium or titanic acid in samples of cast or wrought iron, this substance has usually been sought for in the residue insoluble in acids, but the following experiments also prove that such a procedure cannot be relied upon as furnishing correct results.

A sample of cast-iron produced from smelting a titaniferous magnetite from Gullaxrud, in Norway, in a charcoal blast furnace, was taken, and 251·59 grains in small fragments dissolved in nitrohydrochloric acid ; the insoluble residue was collected on a filter, incinerated, digested with sulphuric acid, and the titanic acid present determined as before described, when it was found to amount to 0·52 grains, equivalent to 0·207 per cent. titanic acid or 0·126 per cent. titanium.

The filtrate was now neutralised carefully with ammonia, and then a slight excess of ammonia added, so as to cause a small permanent precipitate of sesquioxide of iron to be formed, which was then filtered off from the ferruginous solution and washed. This precipitate, which contained all the titanic and phosphoric acid present in the iron, along with an excess of sesquioxide of iron, was now dissolved in a little very dilute sulphuric acid, some nitric acid added and the solution boiled; an immediate precipitate of titanic acid was formed which, when determined, amounted to 0·14 grains, or 0·056 per cent., equivalent to 0·034 per cent. titanium. The examination of this cast-iron resulted in showing that it contained 0·207 per cent. titanic acid in the insoluble form, and 0·056 per cent. titanic acid in the soluble form, or a total of 0·263 per cent. titanic acid, and that, consequently, more than 20 per cent. of the entire titanic acid had been dissolved by the acids employed in the analysis.

Another sample of cast-iron produced from smelting the titaniferous magnetite from Christine Mine, near Krageroe, in Norway, was also examined with the same object in view. In this case 104·26 grains of the cast-iron in fragments were dissolved in nitrohydrochloric acid, and left an insoluble residue which, after incineration, weighed 2·47 grains ; this was, as in the last case, digested in concentrated sulphuric acid ; the titanic acid, which was determined as before described, weighed only 0·02 grains. The acid filtrate was then treated with ammonia, so as to precipitate a small amount of the sesquioxide of iron along with any titanic acid contained in the iron, and this latter determined as in the former case, amounted to 0·03 grains.

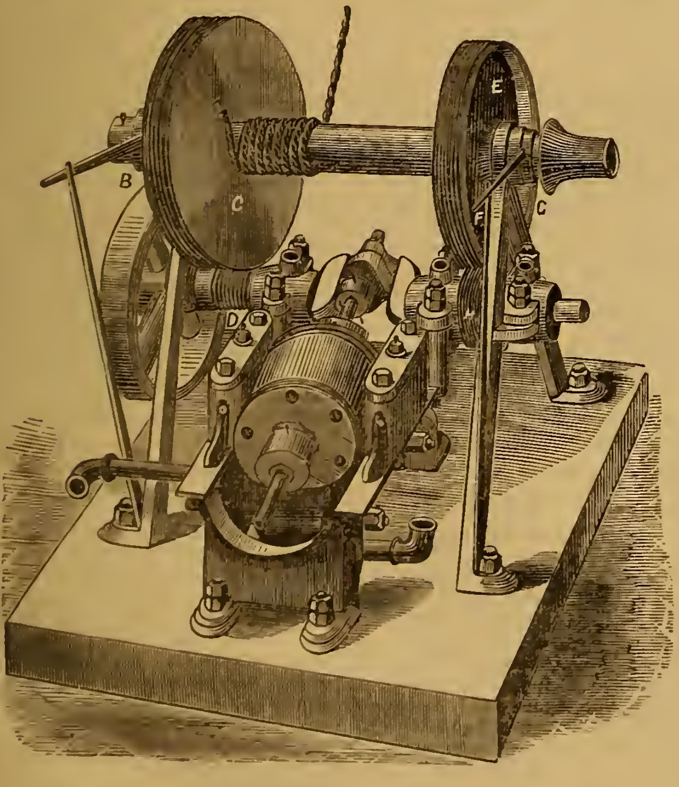
The result of this experiment shows, therefore, that this cast-iron contained a total of only 0·048 per cent. titanic acid (equivalent to 0·029 titanium) of which 0·019 per cent. remained in the insoluble residue, whilst 0·029 per cent. had been dissolved in the acid solution, confirming the previously arrived at conclusion, that when a very small amount of titanic acid is present in the substance, the major part of it is often, if not always, to be found in the solution, and not in the insoluable residue.

I have not been able as yet (although I have made several experiments for the purpose), to prove satisfactorily that titanium alloys with iron, but the analysis of various samples of cast-iron, wrought, bar, and steel smelted from ores containing titanic acid in considerable quantity, appear rather to indicate that the small amount of titanium which they really do contain, is mechanically associated with the iron probably in an oxidised state, than present as a true alloy with the iron itself.

## ANDREWS' PATENT DIFFERENTIAL FRICTION HOIST.

The annexed wood-cut represents a hoisting machine adapted to very heavy work and applicable to all the various purposes for which such apparatus are generally employed. The construction and operation of the machine are thus set forth by the inventor in the *American Artizan* :—

"The drum is provided with two large wheels, E and C, of different diameters (rigidly attached thereto), with wedge shaped grooves extending around their peripheries and occupying the whole width of their faces. The bearings of the drum-shaft are in eccentrics secured in boxes in the main frame, within which they are turned by means of levers, A and B, attached to them.



"Upon the engine shaft, which is parallel to the drum-shaft, are small wheels or pinions, D and H, also of different diameters; corresponding with the difference in diameters of wheels, E and C, and having grooves upon their faces corresponding with, and fitting into, those upon the spur-wheels. The pinions are attached to the engine-shaft by feathers, admitting of some play, to allow them to accommodate themselves to the rigidly secured spur wheels upon the drum. The levers upon the eccentrics are either made elastic or attached to a spring, permitting a slight movement of the wheels to and fro, when in contact with the pinions, to compensate for any unevenness in their surfaces, caused by wear or otherwise. Each wheel and pinion has its face slightly out of line with its shaft, to compensate for the movement of the drum-shaft to and from the pinions at alternate ends, and to keep the faces of the wheels and their teeth in perfect contact, each when in its proper working position. A friction-brake to work with the foot is placed in contact with the face of one of the spur-wheels. On one end of the drum-shaft is placed a short fleeting drum, to be used as a gipsy-winch.

"It is evident that, if the two pinions are simultaneously in contact with the two spur-wheels, no motion can ensue, as they act as friction-brakes upon each other. The engine being started, and regulated by a governor, the mode of operation is as follows:—It being required, for instance, to raise a light weight, the lever, B, upon the eccentric, next the large wheel, is raised until it takes into a spring catch, which maintains wheel, C, above, and out of contact with its pinion, D. At the same time the lever on the eccentric near the spur-wheel, E, is depressed until the wheel is brought into close contact with its pinion, H, in which position it is retained by a spring catch, and is rotated about one revolution to three of the engine. Should it be required to raise a heavier weight by raising lever, A, and depressing lever, B, the wheel, E, is thrown out of contact with its pinion, and the larger wheel, C, is brought in contact with the smaller pinion, D, in which position it is held by the spring lever taking into a spring catch; and it receives a motion of one revolution to nine of the engine, increasing the power in the ratio in which its motion decreases. The proportions of the wheels may be varied to any extent. This machine runs without noise, consumes less power than coarse friction-grooves or toothed gear, and is not liable to break or get out of order. It gives two motions, or powers, which can be changed instantaneously, one for the other, without any extra strain or jerk upon the machinery—making it operate in a superior manner. As arranged with the oscillating engine, made by the same manufacturers, it is very light and strong, and occupies less room than any other style of the same capacity.

## UNITED STATES PATENT OFFICE.

It will be seen from the circular issued by the commissioner of the Patent Office of the United States that he has conceived the laudable idea of making for his library a gigantic collection of literature orignally intended for advertisements but which become valuable as they grow obsolete, Thus it is both interesting and instructive to compare drawings and estimates of various manufactures, &c., of twenty years ago with those of the present date, or to trace year by year the various stages of improvement any particular manufacture has undergone from its origin up to this time. There are various other uses of such a collection which need not be mentioned as they are alluded to in the circular; but we may, perhaps, be permitted to hint that it might be worth the attention of the authorities at our own Patent Office.

"It is desirable, for purposes of reference, to obtain for the library of this office, copies of all illustrated catalogues, price lists, and circulars. In many cases, where no illustrations are given, such lists and catalogues are of great service in determining the meaning of words used in the arts, and for other purposes.

"It would seem particularly appropriate that the library of the Patent Office should be made a place of deposit for this unrecorded literature of the arts, which would otherwise, in a few years, be entirely lost. Some of the most valuable books in the library are such lists, some of them now fifty years old.

"That such a means of preserving for all time pamphlets of this sort is offered, should alone be an inducement to all interested to aid in making this collection as complete as possible.

"Three copies in general should be sent, one for permanent deposit in the library, and two or more for the use of the examiner; but all of them to belong to the library, and to be in charge of the librarian.

"When successive editions are published, each new one should be sent.

"Everything of this kind directed to the Commissioner of the Patents, Washington, and sent to the care of his agents, Stevens Brothers, 17, Henrietta Street, Covent Garden, London, W.C., will be most thankfully received by the Commissioner."

## SHIPBUILDING ON THE TYNE.

The following is a summary of the iron ships built at the principal shipbuilding yards on the Tyne during the year 1868:—

At South Shields—The *John Smart*, the *Twist*, *Marian*, *Paulin*, and *Catherine*, all powerful steam tugs, for Constantinople; the *Stanley* and other steam tugs for home trade; the iron screw steamers *Arcadia* and *Peri* for the Orkney mail service; the tug *Lord Warden* for the Thames; the *Kingfisher*, 120-horse power, for Liverpool; *Sir Robert Napier* a sailing vessel, classed for 12 years; an iron sailing vessel. *Carical*, for Nantes, and the clipper built iron ship *Peri*, for South Shield owners. Orders are on hand for some more tugs for Constantinople, and mail steamers for the Orkneys; also the *Constantine*, 50-horse power, for Galatz, and *Robin Hood* for Genoa; *Maggie Smart*, 60-horse power, for

Constantinople; and *Robin Hood,* to trade on the Tyne; and the *Flying Sprite* for the Clyde.

At Jarrow—14 large iron ships, including four sailing ships—the *Porticia Knight Bachelor, Treasure Trove,* and *Beau Ideal,* each over 1, 400 tons; a large fine steam yacht, for Earl Vane; also the *Hellas,* 80-horse power, for Constantinople; iron-clad Monitor war screw steamship *Cerberus,* for Melbourne; the *Alexius Acatosa* screw steamer, of 90-horse power, 867 tons, built for the Grecian trade; the *Nevada,* a large iron screw steamship, for the Liverpool and Great Western Steam Shipping Company, of Liverpool and New York; and five other powerful screw steamers for general trade. The amount of tonnage launched at Jarrow during the year amounts to 16,728 tons, and the horse power of the steamers amounts to 1,440. In addition to the foregoing, there are about 5,000 tons of Shipping at Jarrow ready to launch, and 8,000 tons more in various stages.

At Hepburn a large number of vessels have been launched during the year, amongst which was the *Neva,* a large screw steamer of 2,500 tons, for Liverpool, intended to trade between Bombay and Suez; two large screws for Liverpool, and a large paddle steamer for the London and North Western Railway Company, to carry passengers between Holyhead and Dublin. Ten various-sized iron vessels besides are now on the way at Hepburn in course of construction, including two large ships for a Russian company, and six barges for the Russian trade.

At Willington 36 steamers have been on the slipway, principally vessels ove 1,000 tons each, including the *Princess Alice,* now trading between Aberdeen and Hull, which was lengthened 20ft. The tanks were built at Willington for the Archimedes screw steamer, which laid the telegraph cable between Denmark and Newbiggin-by-the-Sea.

At Wallsend—*Pfeil* screw steamer, 780 tons, 80-horse power, for the coal trade; *Keilder Castle,* for the Northumberland Steam Shipping Company, 936 tons, and 100-horse power, for the Mediterranean Trade; *Leckwith,* 556 tons, 75-horse power, for the Spanish Trade; one, 1,252 tons, for the Indian and China Trade. There are on the ways now at Wallsend one sailing ship, of 1,250 tons; one screw passenger steamer, of 800 tons, and 100-horse power; and one screw, of 550 tons, and 70-horse power.

At Low Walker—A number of iron steamers, ranging from 36-horse power to 90-horse power. The list includes a paddle steamer for the Northern Lighthouses; a mail steamer for the Norwegian service; a paddle tug for the Danube, for the Tanias Company, Rostoff, on the Don, where, it is said, large coalfields have recently been found; a steamer for Constantinople; one specially designed to carry pyrites from Norway; and others for the Baltic Trade. Several others are on hand, including orders for the Tanias Company and the Norwegian Mail Service.

At Walker (High)—One steamer, of 519 tons, for Norwegian Mail Service; one steamer, of 102 tons and 15-horse power, for the Indian Government; six steamers, of 5,439 tons and 600-horse power, for British Owners, for home and general trade; five steamers, of 1 728 tons and 385-horse power, for Russian service on internal seas and rivers in that country; eight sailing barges, 7,844 tons, for Russian service. At present building—One screw steamer, of 794 tons, for Norway; two paddle steamers, of 541 tons for Russia; four screw steamers. for British Owners; and one sailing vessel, of 825 tons, for British Owners.

During the last 12 month, 16 sailing ships have been added to the registry of the Port of South Shields. Five of these are new ships built in the Wear, of the respective tonnage of 262, 237, 368. 456, and 193 tons—new tonnage, in the whole, 1,516 tons. The other 11 added to the registry were built previous to 1868, representing 6,428 tons; six of these ships are American built—one, 1,012 tons, built in 1853; one, 1,243, built in 1854; one, 1,054, built in 1858; one, 634, built in 1856; one, 742, built in 1852; and one, 414, built in 1843. The whole tonnage to the Port of Louth Shields amounts to 7,944 tons; and during the year there have been lost or withdrawn from South Shields Registry 22 vessels, representing 8,450 tons. The result, therefore, shows a small diminution in the aggregate of 506 tons less Shipping belonging to the Port of South Shields than in 1867.

At Middlesborough, last year, eight vessels were added to the Registry of the Port, representing 1,518 tons, all of which were built at Middlesborough except one, which was built at Stockton. During the year six ships were lost or withdrawn from Middlesborough, representing 1,346 tons. The gross tonnage now registered at that Port, therefore, has been increased, as compared with 1867, by 172 tons.

**Passenger Traffic between France and England.**—The number of passengers to or from France and Eugland by the four principal ports for that traffic, was as follows during the year 1868; Calais, 142,221; Boulogne, 109,365; Dieppe, 35,577: and Havre, 19,206.

## THE GAS SUPPLY OF THE CITY.

Dr. Letheby has made a communication to the Corporation of London on this subject. In July last an important Act of Parliament was passed for improving the quality of the gas supplied to the city of London by the several city gas companies, and also to those parts of the metropolis supplied by the Chartered Gas Company, whereby the quality of the gas was raised from a standard of 12 candles to 14, without increase of charge to the consumer; and with the view of securing the provisions of the Act and enforcing penalties in all cases of default, a chief gas examiner is appointed by the Board of Trade to receive the reports of the daily testing of the gas, and to decide all matters of dispute respecting the quality of the gas. It is also the duty of the chief gas examiner to report to the Corporation, to the Metropolitan Board of Works, and to the several companies the quality of the gas supplied during the quarter, and in this capacity, and in accordance with the provisions of the 71st section of the City of London Gas Act, 1868, Dr. Letheby has recently submitted his report to the Corporation of London, from which it appears that since the Act came into operation on the 1st of October last the gas of the several companies supplying the city has been tested every night, at intervals of not less than an hour, between the hours of 5 o'clock and 10 o'clock. The results are as follows:—Illuminating power in standard sperm candles.—City of London Gaslight and Coke Company—maximum, 16·30; minimum, 13·99; average, 15·13. The Chartered Gaslight and Coke Compauy—maximum, 16·36; minimum, 14·13; average, 15·26. The Great Central Gas Consumers Company—maximum, 16·64; minimum, 13·46; average, 14·90. It appears, therefore, that the illuminating powers of the gas has ranged from 13·64 to 16·64, the average for the quarter being 15·13 for the City Company, 15·26 for the Chartered, and 14·90 for the Great Central. The daily returns show that on three occasions only the gas has been below the standard, and these were no doubt due to causes which admit of satisfactory explanation. With regard to the purity of the gas he reports that the gas of the Chartered and Great Central Companies have always exhibited traces of ammonia, but that the gas of all the companies has been constantly free from sulphuretted hydrogen. The amount of sulphur present in the gas has ranged from 7·9 grains to 26·52 per 100 cubic feet, the proportions of the impurity being as follows:—Grains of Sulphur per 100 cubic feet of gas—City of London Gaslight and Coke Company—maximum, 22·28; minimum, 10·64; average, 16·89. The Chartered Gaslight and Coke Company, maximum, 26·52; minimum, 11·01; average, 21·93. The Great Central Consumers' Company—maximum, 24·94; minimum, 7·90; average, 14·24. The smallest amount of sulphur has been in the gas of the Great Central Company, and this is attributed by Dr. Letheby to the excellent system of purification adopted by that company. The proportions of sulphur have been determined by the instrument known as Dr. Letheby's sulphur test, which is that recommended for use by the Gas Referees appointed under the Act. It is extremely desirable that this impurity should be reduced to the smallest quantity, on account of the corrosive action of the products of its combustion.

## TESTIMONIAL TO MR. ROBERT NAPIER.

Nearly three years ago a proposal was made by Mr. J. J. Bagshawe, Mr. W. Smith, and a few other leading members of the Institution of Mechanical Engineers, to present to Mr. Robert Napier a testimonial, both as a mark of esteem as an old president of the institution, and as a recognition of his valuable services in the cause of marine engineering. This proposal was readily responded to, and it was, after due consideration, resolved that the testimonial should take the form of a bust, as being the most suitable present to one whose works will live after him. The "Napier Bust," by Wyon, which, so far as we can judge, is a life-like likeness, was presented to him on the 16th of December last, just in time for the celebration of his golden wedding day; and we trust that he may long be able to point with satisfaction to this acknowledgment of his having performed his share in the advancement of engineering.

## BRITISH ASSOCIATION.

### ON THE ABRADING AND TRANSPORTING POWER OF WATER.

By T. Login, Esq., C.E., F.R.S.E, Executive Engineer, D.P.W., India.

The abrading and transporting power of water in motion, is one of the most important agents Nature has employed in adapting the world for its present inhabitants.

The geologist acknowledges that the greater portion of the crust of this globe has been transformed by this agency; yet it does not appear that the force exerted in bringing about these great changes has been the subject of special investigation. We have simply acknowledged the fact.

The power derivable from water in motion has been known from the earliest ages, and has been taken advantage of by man; and also the resistance water offers to a body passing through it, has been the study of our greatest philosophers; but our attempts to establish the laws of Nature, which regulate the motions of fluids up to the present day, leave much to be desired.

No better proof of this can be given than the controversy now going on regarding the Great Ganges Canal between the greatest engineers India has yet produced during our rule; one maintaining that what is called the Madras system is the only correct one—namely, slow velocities; and the other, that that system is not adapted to Northern India. On the correct settlement of this dispute great interest depend, for not only is it a subject for the philosopher to study, but also for the politician, the philanthrophist, and Christian, as the future prosperity of this great continent is bound up in it.

This is not the place to speak of how the welfare of such a large portion of the human race depends on canals properly constructed, but it is well not to lose sight of it. The object of the writer on this occasion is to draw attention to the abrading and transporting power of water, which appears materially to effect the flowing of water under all circumstances.

Eight years ago, on my return to the Ganges Canal, an old intelligent native foreman brought to my notice that the canal bed was always much deeper in March than in October—that is, the bed got partially silted up during the hot season while the Ganges was in flood, which silt was swept away, when the water in the river became pure in the cold season. Also in making some experiments on the Solani Aqueduct on the relative velocity of the surface, mean and bottom velocity (the result of which will be found in the table appended) I found that a deposit of sand had actually taken place where the bottom velocity was three times what would be sufficient for transporting sand.

Twelve years ago I had the honour to draw the attention of the Royal Society of Edinburgh to the apparent discrepancy between surface, bottom, and mean velocities in my paper on the Irrawaddy. The above facts also, therefore, only led me the more to doubt the accuracy of the most important hydraulic rules. It was not, however, till a very recent date that my attention was accidentally drawn to the vast amount of power Nature must exert in transporting the *debris* of the Himalayas to the Bay of Bengal; and, with its permission to publish them, I now take the liberty of bringing to your notice some arguments which go to prove that the slope required to be given to artificial rivers must vary in accordance with the proportion and quality of the earthy matter held in suspension by the water. With the Madras canals only slight slopes of 5 or 6 inches in the mile are necessary, for there the rivers roll down coarse sharp sand from hills formed of primary rocks, for the surface water (except in the very highest floods, when the canals would be closed) would comparatively be pure all the year round.

Our rivers of Upper India, on the other hand, flowing, for the greater portion of their course over rocks of more recent formation, must naturally hold a much larger proportion of earthy matter in suspension; consequently, a much greater power—in other words, slope—must be given to our canals in Upper India. Thus both Sir Arthur Cotton and Sir Probey Cantley were right, the former in adopting the ancient mode of irrigation of the old Hindoos in Southern India, and the latter in following in the footsteps of that great Mahomedan canal engineer, Ali Murdan Khan, who flourished some two centuries ago, and has left behind him several canals to testify to his ability, and the flourishing state of India in his time.

Fortunately, Nature has stepped in and asserted her rule in rectifying the canal bed as soon as the slope was brought back to about what was originally designed—namely, 15 inches in the mile, or about three times the gradient necessary in Madras. By establishing this fact, it also becomes self-evident that, though irrigation canals in Southern India are adopted for navigation, in Upper India the velocity of the stream is necessarily much too great to be easily navigated.

Having thus pointed out that Nature has asserted her right, I take the liberty of making some extracts from a memorandum I submitted to government; and as it brings in a new element in our calculations for determining under what conditions water flows, I trust the following may not be without interest, and, if the theory be based on facts, may lead those of you who take an interest in the subject to further investigate the matter, and arrive at results which are quite beyond my powers:—

First, therefore, all our rules are the deductions from experiments made on pure and clear water—a state of things we seldom meet with in nature; but if we throw into a vessel containing water some foreign matter, and attempt to uniformly mix this matter in the liquid, we know that a considerable amount of muscular power has to be exerted; the question naturally asked, therefore, is: Has not Nature also to exert this force, and is not the water retarded in its flow by having to use this power, though this may be too small to be observed in many cases?

The next step is to try and discover what is the force required in transporting earthy matter down an inclined plain when water is the sole agent by which it is carried—or rather what is the quantity of earthy matter which water of given depth at given declivities can carry down by holding this matter in suspension. Now, at starting we are met with a difficulty, as this must depend on two circumstances:—

1st. The specific gravity of the matter held in suspension.

2nd. The shape of these particles as well as their size.

Therefore the transporting power of water over the bed must depend on the nature of the earthy matter to be transported, as well as the velocity of that water; and it is evident also that, owing to the enormous force required for the conveyance of this matter, the water must be retarded, or in other words, dirty water requires *greater slopes* for the same velocity than pure water.

As an extreme case when water contains so much foreign matter as to become a thick mud, it can't travel except at excessive slopes; but was this water freed from this earthy matter it would immediately rush past at enormous velocities, tearing up rocks or whatever came in its way, and this would continue till such time that it had collected enough matter for the force required to transport it, so as to retard its velocity and establish the necessary equilibrium. Thus the same water may again pass over ground with very excessive slopes without doing any injury, even though the soil may be light, which, if the water was pure, would tear up the stiffest clay soils—nay, should there be a slight decrease in the slope there would be found deposits, and no sooner is this water lightened of its load, than it is ready to rush off again, tearing up the ground till a balance is again established.

This example is just what we find to be the case with some of our mountain torrents, such as the Puttree Nuddie, where, with slopes of 25ft. in the mile, we have deposits taking place rather than a cutting away where it crosses the Ganges Canal. We also find that, owing to these deposits, the course of the torrents is often diverted, and it was owing to this that there was so much difficulty in keeping the torrents to one course.

It is by examining extreme cases like the above that we the more certainly arrive at some explanation why certain changes occur, where the causes at first sight are not so apparent as where they are distinctly marked. The deduction to be arrived at in the present case is, any reduction in the slope of a silt-bearing stream will at once cause a deposit in the bed, which will, as a matter of course, cause continuous changes in the channel.

Having got so far—namely, that water in motion can transport only a given quantity, or quality of matter with given velocities and no more, we may now test it by experiment.

Take for example a clear running stream with such a velocity that it is in the act of just rolling down grains of coarse sand (coarse sand can be moved by pure water with a bottom velocity of one foot a second, and newly-deposited clay with half that velocity.) Take and mix a quantity of earth with the water of the brook a little higher up, and we shall at once find there is a deposit taking place of a light alluvial soil on the top of the coarse sand which was before in motion. This will continue so long as there is an over abundance of earthy matter, till at last the bed gets so silted up that the stream will begin to change its course, going from side to side, cutting new channels for itself through the mud bank. Leave it, however, to itself again, and we shall find all this mud disappear, and things come back to their former state. The coarse sand will again be exposed to the action of water.

Now let us see how this acts in nature on the large scale. First, we have rivers rushing over rocky beds, rolling and pushing forward large masses of rock. These again get broken up into boulders, to be still further ground down to pebbles, and ultimately sand, in which state it is to be found a few miles below the hills. This coarse sand, so much of it as the river can carry forward, is transported direct to the sea, but a large quantity is left behind, forming sand banks in the river, thus causing constant changes in the course of the stream, that no two years is it alike. If the state of things continued, and the river was in constant flood, we should soon have the river raising its bed; or on the other hand were there to be no floods for a series of years, and only pure water, as in the cold season, escaping from among the hills the river beds would be much deepened. Nature, however, so balances matters that, so far as it affects us, the average levels of the bed and the surface of the water remain constant.

Speaking roughly the Ganges and all the rivers of Northern India which are fed by the melting of the snow, may be said to be six months in flood, and the remaining six, the water is pure, being fed from springs. The discharge during the hot season being ten times that of the cold.

With a canal, therefore, like that from the Ganges, fed from a river under such variable circumstances, it is evident that it must be adapted to these circumstances to be found only by experience.

On an average it may be said that the Ganges canal was formerly running at a slope of nearly 18in. in the mile if not more, in the first division, instead of 15in., as intended. There was great abrasion on the bed and banks of the canal, and there was a regular cutting back on the works to a dangerous extent above Toogulpore, or say, for the first 40 miles. Below this and for the next 10 miles matters appeared balanced, and at Jowlee there was a deposit to a considerable extent, so much so, that below the regulator the stream began to look for new channels for itself, which it could the more readily do, as here the country was all of a light sandy nature. In spite of all attempts to prevent this, the stream cut some 500 feet into the right bank, and the channel itself had silted up some five or six feet.

This sand deposited on the bed was at this time of such a shifting nature, that it was difficult to determine, either by lead, or measuring rods the correct depth of water. This water also was so turbid that a rupee was lost sight of at 15in. below the surface. No sooner, however, was the surface slope of the water higher up brought back to the original intended slope than a very great change took place. The main body of the water was soon brought back to the main channel. The sand over the bed was no more shifting. There was in fact a cutting on the tail of the Jowlee falls, and a rupee can now be seen at depths exceeding 2ft. below the surface. Higher up again all dangerous cuttings of the bed, and falling in of the banks is put a stop to, and the holes below the bridges, which formerly extended to below the level of the foundations, silted up to near level with the floorings, and all along the bed there was a deposit rather than a cutting away. The mean velocity which over the Solani Aqueduct was nearly 4½ft. a second with a full supply, was reduced to 3¾ft., in short the velocity became such that all immediate danger has disappeared, and the canal has been running with a large supply for some time back.

In arriving therefore at a conclusion, with the above facts as our guide, the question we would naturally ask ourselves is this :—Has not the proportion of earthy matter held in suspension by the water in the river, from which the supply for an irrigation canal is obtained, everything to do with the slope required to be given to the canal?

Not to lose sight of these facts it will be better to state them again in order :—

1st. All silt-bearing streams when in train only transport a given proportion of earthly matter.

2nd. That this proportion depends on the velocity and the nature of the material transported.

3rd. Any increase to the velocity must cause a tendency to cutting and decrease to deposit.

4th. That a silt-bearing stream is retarded by having to exert a force sufficient to transport this earthy matter, consequently the slope acquired for a given velocity under such circumstances must be greater somewhat than if the water was pure.

From the above, therefore, we may make the following deductions :—

1st. That a certain velocity can only transport certain proportions of certain descriptions of earthy matter; that there should be one uniform slope, as far as practicable, given to an artificial river which has to transport earthy matter.

2nd. That as the stream when in train cannot pick up or deposit any of this earthy matter, it signifies little if the canal be flowing through a sandy or clay channel, so long as the particles held in suspension are not heavier than those of the bed. Where they are heavier, simply an exchange will be effected, and where they are not, no action can take place; for should there be any deposit from a superabundance of earthly matter this fresh deposit will be most easily picked up when the water again becomes more pure in the dry season.

3rd. That should the train of the stream be materially effected—that is, should the velocity be reduced along any portion of the course of the stream a deposit on the bed must take place at this point, and, as a natural consequence, a constant changing of the channel must follow, unless prevented by a constant outlay to counteract these changes.

4th. That no sooner is the stream lightened of its burden at this point of its course than it will flow with greater rapidity lower down, particularly if the slope be somewhat again increased. Consequently, there must be an action on the bed where this takes place with a corresponding silting up further down. Thus by introducing irregularity in the flow of the stream' a corresponding irregularity in the bed of the canal must, as a natural consequence follow, which once begun must go on extending and increasing.

What, therefore, appears to be necessary in the case of the Ganges Canal, and all other canals in Northern India, is to give the canal such a slope that it will carry forward, and deposit uniformly over the upper half of the canal bed, half of this earthy matter, which enters the canal during the hot season, and then in the cold weather, when the water is pure, pick up this deposit and carry it down also; or there should be the means of increasing the slope when the water is turbid, and reducing it when the water becomes pure.

Now, as we see such favourable results by only reducing the slope of the surface of the water 3in., or rather when we see so much injury was done as to endanger the works by increasing the slope only some 3in. over what the projector by his experience considered the extreme limit of safety, is it not probable that only a very little reduction more is necessary, probably not more than 2½in. at the farthest, so why not, at all events, try this in the first instance before we determine on introducing such radical changes, as in some instances reducing the slope more than one-half, which may lead to most serious results, which only can be discovered when too late?

If a slope of 12in. in the mile be necessary to carry forward the earthy matter of the Ganges, it is evident that it is needless to think of drawing off a supply from a point so low as Sookurtall, as the irrigation of the Doab could not commence higher up than the district of Cawnpore.

Nay, further, is it not a waste of time calculating out projects with only one-third of the required slope, and have we not constant examples with our inundation canals that the slopes, though far exceeding 4in. in the mile (I may say 8in., and in some cases even 12in.) do constantly get silted up for want of the required velocity to carry onward the earth held in suspension in the water of our rivers of Northern India?

The foregoing paper is chiefly extracts from the memorandum I submitted to Government in June, 1866, as an appendix to my evidence before the Special Committee on the Ganges canal, which committee after due consideration came to the conclusion, "that by slightly raising each set of falls, so as to reduce the surface slope by about 1in. per mile, the present excavation will generally answer, and a considerable outlay will be saved."

I need hardly add that this has been approved of by the Home Government, and the change which I introduced in 1862-3, referred to in the body of this paper, still continues to act favourably, a detailed account of which will be found in the proceedings of the Institute of Civil Engineers.

In conclusion, I should state that during the last two years I have had opportunities of watching several floods, and in October last I had the fortune of seeing the Ganges Canal bed laid dry.

What I have seen on these occasions, instead of modifying my views, has confirmed them, for the more I have studied the subject in all its bearings, the more I feel satisfied of the correctness of the conclusions I have arrived at, namely, "that certain velocities can hold in suspension a certain load of silt, and this load cannot be changed, whatever soil the current flows over, be it hard rock or loose sand: with any increase to the velocity there must be a tendency to abrasion, with a decrease to deposit."

The practical conclusions to be arrived at, if this be correct, are most important, and go far to simplify matters, not only in the construction of irrigation canals, but also in dealing with flowing water, under all circumstances, for we have only to go and study nature under similar circumstances. In the case of an irrigation canal, the river from which the water is obtained at once becomes our guide, or where a river has to be bridged it will be no longer necessary to make detailed surveys of catchment basins, and keep extended registers of rain fall, which at best are but approximations, and are open to a great amount of error.

Nature knows best how great a load of silt can be carried, and we may rest assured that wherever she is not obstructed the proper load to the velocity and depth has been already supplied, so it matters little if the velocity of a river be 2, 4, 6, 8, or even 10 feet a second, so long as we do not increase or diminish that velocity, at the point were the stream leaves the work, be it a bridge, or wear, anicut, or tumbling bay.

What the engineer therefore has to do is to give the same sectional area of water way that the river may have at its narrowest point below the work, taking care that the water flows off smoothly, that is, that there be as few eddies as possible on leaving the works, but as this rolling or whirling motion cannot, on all occasions, be avoided, a slight increase of sectional area is necessary.

Again, in nature we never find water flows in straight lines, but has either a whirling, or what appears to be a rotary motion, that is, any particular particle of water moving down a stream would follow the course of any point on the perimeter of a carriage wheel, rather than that of the axes. Possibly, therefore, as the friction of dragging a carriage decreases as the diameter of the wheel increases, so may the velocity of the stream increase with an increase of depth, the slope remaining constant.

This may account also for the reason why in water with about the same mean velocities, but of different depths, the transporting power of the stream of earthy matter is in some inverse ratio to the depth. Thus the Irrawaddy, the Solani, Ratmoo, and Puttree have all nearly the same velocity in flood, about five miles an hour, but the Irrawaddy, with a depth of upwards of 70ft. only transports 1-1700th of its weight of earthy matter; the Solani, with about 10ft. deep some four per cent., the Ratmoo 8ft., 5 per cent., and the Puttree 5 feet, 7 per cent.

In other words, this rotary motion in shallow streams is greater than in deep ones, and consequently shallow rivers have a greater power to transport earthy matter, with the same velocities.

It has been stated that water in nature never flows in straight lines, so in passing over or through a work, it cannot signify much what is the shape of the sectional area on such occasions, so long as it is again able to assume the same section, as it has in nature at the point of leaving a work. It is therefore evident the depth may be increased, and the breadth decreased where a river is bridged, and a considerable saving effected under due precautions without danger. While, with a weir, by increasing the length of lip the bed may be raised at that point without disturbing the flow of the river either above or below the work.

*Table showing the surface, mean, and bottom velocities over the Solani Aqueduct in February*, 1862, *when there was 7ft. at the Roorkie Bridge, and the proportional differences of these velocities at every 7ft. across the the channel.*

| Distance in feet from left side of Channel. | Velocity in feet per second. | | | Proportions of differences. | | | Remarks. |
|---|---|---|---|---|---|---|---|
| | Surface. | Mean. | Bottom. | Surface. | Mean. | Bottom. | |
| 0 | 3·00 | 2·80 | 2·60 | 100·00 | 93·33 | 86·66 | The depth of water over flooring of aqueduct was 8·20ft. The slope of surface of water was 1·005ft. in the mile at the point of observation. |
| 7 | 3·50 | 3·30 | 2·95 | 100·00 | 94·28 | 84·28 | |
| 14 | 3·85 | 3·60 | 3·25 | 100·00 | 93·50 | 84·42 | |
| 21 | 4·15 | 3·80 | 3·45 | 100·00 | 91·56 | 84·09 | |
| 28 | 4·35 | 4·00 | 3·50 | 100·00 | 91.95 | 80·46 | |
| 35 | 4·55 | 4·15 | 3·55 | 100·00 | 91·09 | 78·02 | |
| 42 | 4·75 | 4·35 | 3·60 | 100·00 | 91·58 | 75·79 | |
| 49 | 4·90 | 4·50 | 3·65 | 100·00 | 91·86 | 74·49 | |
| 56 | 4·95 | 4·55 | 3·70 | 100·00 | 91·92 | 74·74 | |
| 63 | 5·00 | 4·55 | 3·75 | 100·00 | 91·00 | 75·00 | |
| 70 | 5·00 | 4·55 | 3·80 | 100·00 | 91·00 | 76·00 | |
| 77 | 4·80 | 4·45 | 3·70 | 100·00 | 94·79 | 77·08 | |
| 84 | 4·40 | 3·90 | 3·40 | 100·00 | 88·64 | 77·27 | |
| Average | 4·40 | 4·04 | 3·47 | 100·00 | 92·04 | 79·10 | |

The above results, however, are obtained from a perfectly smooth, uniform channel, with perpendicular sides, and having no obstructions from either bends or irregularities of the bed, taken during a perfect calm, with a volume of water nearly equalling 3,000 cubic feet a second, passing down each channel.

We must, therefore, expect a greater mean velocity in proportion to that of the surface, than in a river with bends and an irregular bottom. In all the experiments on the Ganges Canal, it was found that the mean velocity exceded the the calculated mean velocity ($b = (\sqrt{s} - 1)^2$ and $\frac{s + b}{2}$ = mean velocity, as given by Beardmore), and it will be found that as the depth increases so will the difference between the surface and mean velocities decrease, and that between the surface and bottom increase.*

## THE LONDON ASSOCIATION OF FOREMAN ENGINEERS.

The sixteenth annual meeting of members took place on Saturday, the 2nd ult. It was exceedingly well attended, and the chair was occupied by Mr. J. Newton. The first business of moment consisted in the presentation of the balance sheet of the last half year, and the report thereupon of the auditors—Messrs. Irvine and Bulleugh. From these documents we gather that the Association, in spite of the continued depression of trade, is in a satisfactory condition, numerically and financially. The number of ordinary members is 104, and of honorary members 64—total, 168. The general fund, invested or in hand, amounts to £129 2s. 11d., and the superannuation fund—the interest upon which only is available for the partial support of decayed foremen—equals £903 18s. The fund for the solace of widows and orphans is very minute, amounting to £10 only. It is subscribed to homœopathically, to all appearance, by ordinary members solely. During the past year, £103 were paid to unemployed associates, and £33 as solatia to the families of those who died in the same period.

The balance sheet and report were, after some discussion, unanimously accepted. Mr. Briggs having explained the nature and agreeable results of his visit to the Leeds Association of Foremen, which, too, is in a thriving condition, Mr Newton proceeded to deliver the president's annual address. This was of considerable length, and of much interest, but it is not possible for us at present to give it *in extenso*. After alluding to the gratifying fact that the Institution is steadily progressing and gaining more and more the countenance and support of employers, Mr. Newton furnished biographical sketches of Messrs. Tomlinson and Clark, two associates, whose deaths occurred in 1868. Mr. Tomlinson was foreman of boiler makers at the Royal Dockyard, Woolwich, and Mr. Clark, foreman of moulders to Messrs. Maudslay, Sons, and Field. Details were given of their professional careers, of their personal characteristics, and of their scientific acquirements. It was (observed the president) a matter of regret that the materials for these biographies were scanty, although it was known that both associates had passed through many vicissitudes. "Were we one and all to keep diaries, and make careful note of our labours, our cares, our hopes, our fears, our disappointments, and of our triumphs over difficulties, what interesting and valuable memoirs might not be written, by kindly hands, of the foremen engineers?"

Turning next to the Association itself, the president reviewed its proceedings in the past, and indicated what he considered should be its course in the future. The early efforts made for its establishment had been well sustained by its founders, and the Institution was at that moment healthy and vigorous. Energy and activity, however, on the part of every member were essential for the promotion of its future prosperity. Apathy was the evil to be contended against—the rock ahead which must be removed. "Let but the intellectual strength and the practical knowledge of the associated foremen be put forth and developed in the lecture room as they were in the factory, and their society would take a high place in the estimation of scientific men of every grade. From a knowledge of the materials of which the Association is composed, I am inclined," said Mr. Newton, "to predict that a day will come when the affixing of the initials F.E., as constituting membership, will entitle those who use them to an amount of consideration second only to that accorded to the C.E. and the M.E. It rests with members themselves to achieve this elevated position for the Association."

The necessity of increasing largely the facilities for technically instructing youth intended for the workshop was dwelt upon with much emphasis, and at considerable length, and Mr. Newton concluded his remarks by thanking members generally for the uniform kindness he had experienced on all occasions at their hands. His tenth year of office had now expired, and, as an old hand, he trusted he might retire into private life with a "fair" certificate. Retirement, however, was not allowed to the president on this occasion, for Mr. Newton was at once re-elected to the office on the motion of Messrs. Hosken and Keyte, the two oldest members. Mr. Keyte was re-chosen as vice-president; Messrs. J. Irvine, Cutler, and Dewer were appointed members of the Committee; and Mr. Edmonds, of Woolwich Arsenal, was elected as auditor for the ensuing half year. With a vote of thanks to Mr. Newton for his address, the business of the evening came to a close.

We have since learnt, with much satisfaction, that Joshua Field, Esq., C.E., has consented to preside at the anniversary banquet of the Association on February 20.

## INSTITUTION OF CIVIL ENGINEERS.

### ON MACHINES EMPLOYED IN WORKING AND BREAKING DOWN COAL, SO AS TO AVOID THE USE OF GUNPOWDER.

By Mr. S. P. BIDDER, Jun., Assoc. Inst. C.E.

It was stated that the object of this communication was to direct attention to the 'winning' of coal by mechanical appliances, with the view of obviating the loss in production and the danger to the colliers, which were incidental to the use of gunpowder. Several inventions for this purpose were described, including the machines of Mr. Cochrane, Mr. Chubb, Mr. Grafton Jones, and Mr. Farum; and it was remarked that the great defect in all these machines was their limited expansive power, which did not exceed 3in., and which in practice proved to be insufficient for breaking down a mass of coal in a workable state. Machines for cutting grooves or slots in the coal had also been tried, but it was said only with partial success.

After fully considering these various systems, the author had, in conjunction with Mr. John Jones, devised a machine which had been submitted to actual trial on a working scale at the Harecastle Colliery, where the results were so satisfactory as to induce the proprietors to make arrangements for its immediate adoption. The machine consisted of a small hydraulic press of 12 tons power, to which was attached a pair of tension bars, bent in the form of a connecting-rod or hinge-strap. These were placed one over the other in the bore-hole, and between them, at the extreme end, there were a clearance box and two metal pressing blocks, between which was forced, by the action of the hydraulic press, a split wedge 15in. long, causing a lateral expansion of 3in. The ram was then withdrawn, and a second wedge was inserted between the two parts of the first wedge, and was forced up until sufficient expansion was obtained to break the coal. The operation could be repeated several times if found necessary. The whole apparatus would weigh about 50lbs. The hydraulic press was in future to be made made of steel, and the ram would be cored out. In practical working, each gang of colliers would be provided with the tension bars and three wedges while the presses would be under the charge of the men who at present occupied the position of firemen, so that no new class of labour would be introduced, while the risk of firing would be got rid of. Trials had been made both in the 7ft. and the 9ft. seams at Harecastle; and in the latter, with three wedges, about 12 tons of coal had been brought down in only three or four pieces. It was found that the press could be applied and the blocks brought down in less time than was consumed by firing and waiting for the smoke clearing.

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* As this subject is now attracting considerable attention we think no apology is needed for inserting this valuable paper, though several months old.

Explosions in mines were known to arise, very frequently, from the employment of gunpowder for blasting. In the interests of humanity alone an efficient substitute had long been desired by practical men; and this, it was believed, had been accomplished by the machine under consideration, which had also the advantage of preventing the waste of coal incurred by the present system.

## ON COAL GETTING MACHINERY, AS A SUBSTITUTE FOR THE USE OF GUNPOWDER.

By Mr. C. J. Chubb.

It was remarked that the improvements now needed in the art and practice of coal-mining might be thus specified—first, to ensure greater safety to the men employed in working, and secondly, to obtain the coal in better condition, and, by preventing as much as possible the loss arising from waste, to make more fully available all the remaining resources of the coal fields. It was contended that the use of gunpowder and the operation of blasting must be altogether abandoned; and the problem to be solved was, what force could be applied which should be equally effective, and at the same time break the coal in a more perfect manner. The author thought some more simple and practicable means of getting coal by mechanical power could be devised than the costly, but skilfully contrived, coal-cutting machines. His first idea was to apply wedges, acted upon by hydraulic force, but he was induced to abandon that system, owing to objections to the use of wedges, and to adopt instead an apparatus consisting of twelve plungers, set side by side in a steel bar, which plungers, when acted upon by water from a hydraulic pump, would separate the bar in which they were set from another bar, formed in the shape of a cover upon the plungers. The pressing apparatus was 25in. long, and it was attached to a hydraulic pump by a tube of 2ft. in length, so that it might be inserted into the coal to a depth of about 3ft. 6in. The apparatus, with the cover on, was 4⅜in. in diameter. When, by the action of the pump, the plungers had reached their limit of 2¼in., and further expansion was needed, the plungers were readily brought back to their first position, by opening an escape-cock for the water, when a lever could be inserted between the plunger and the cover; and this process could, of course, be repeated. In practice, however, it was found that the first expansion to 2¼in. was more than sufficient. It was stated that the collective area of the plungers was 24 square inches, and as the pump could exert a pressure of 12 tons on the square inch, a total pressure of 288 tons could be brought to bear on the coal.

This apparatus had been tried in the South Wales district, where the coal was of the most varied description. It was observed that by the present system of blasting, it occupied, on an average, two men ten hours to break down and fill into trams 4 to 5 tons of coal, of which 20 per cent. was "small," and the remainder much shattered. On the other hand, with this apparatus, two men could readily break down 20 tons in one hour, which could be filled, when loosened, at the rate of 10 tons per man per day, the whole of the coal so obtained consisting of large solid pieces. Again, by the present system, in order to break down 500 tons of coal a day, from a "four-foot" seam, a "face" of 600 yards was required, whether as "pillar and stall," or as "long work;" whereas with this apparatus the same quantity could be worked from 300 yards of "face." In this way there would be less space requiring to be ventilated, the working operations could be concentrated, and facilities would be afforded for effecting economy in other respects.

At the meeting on Tuesday evening, the 12th ult., Mr. Charles Hutton Gregory, President, in the chair, fourteen candidates were balloted for and declared to be duly elected, including two members, viz.: Mr. William Anderson, President of the Institution of Civil Engineers of Ireland; and Mr. Frederick William Kitson, Leeds; and twelve associates, viz.: Mr. Christopher James Clarke, Leicester; Mr. Edward Norton Clifton, East India-avenue; Mr. Thos. Dyke, Engineer to the Port and Harbour Commissioners of West Hartlepool; Mr. Richard Massy Greene, Chief Harbour Engineer to the Marine Department of the Imperial Customs' Service of China; Mr. Thomas Hennell, Adelphi; Mr. Anthony Henry Kessner, late Division Engineer on the Union Pacific Railroad; Mr. Francis Langford O'Callaghan, Executive Engineer, P.W.D. of India; Mr. Wilson Weatherly Phipson, Adelphi; Mr. Lewis William Pritchard, Engineer to the Western Gas Light Company; Mr. Warwick Stevens, Darlington Works, Southwark Bridge-road; Mr. William Henry Treverton, Surveyor to the Lewisham District Board of Works; and Mr. Major Vidler, Surveyor and Engineer to the Commissioners of Pevensey Levels.

It was also announced that the following candidates had recently been admitted by the council students of the institution:—John Addy, John Baumann, John Brunlees, Alpin Grant Fowler, Oliver Claude Robson, Robert Sharland, George Stevens, and Joseph John Stiles.

## ANNUAL GENERAL MEETING.

The Report of the Council stated that during the past session there had been twenty-three ordinary general meetings, at which the average number attending had been 244, while in the four preceding sessions the numbers were 155, 175, 192, and 208 respectively. At these meetings papers were read and discussions took place on various professional subjects. These included the benefits and expedients of irrigation of India, Spain, and other warm climates, and on the proper construction of irrigating canals; the manufacture and wear of railway bars; the relation of the freshwater floods of rivers to the areas and physical features of their basins; on floods in the Nerbudda Valley, with remarks on Monsoon floods in India generally; on the Victoria Bridge on the line of the Victoria Station and Pimlico Railway; on new railways at Battersea, and the widening of the Victoria Bridge; the city terminus extension of the Charing Cross Railway, embracing a description of the Cannon-street Bridge and Station; the durability of materials; the supporting power of piles, and on the pneumatic process of sinking iron columns as practised in America; and the experimental determination of the strains on the suspension ties of a bow-string girder. Although the topics thus dealt with had been comparatively limited in number, yet it was believed they might be fairly regarded as representing some of the principal problems now engaging the attention of engineers. There was, for instance, probably no question of greater national importance, having regard to the interests and welfare of so many of the Queen's subjects, than that of irrigation. Hitherto the records of the Institution had been a blank upon this branch of engineering practice; while treatises on the subject, at least in the English language, had previously been almost entirely wanting.

For these communications various premiums had been awarded, which were presented after the reading of the report, including Telford Medals and Telford Premiums of books to Messrs. G. Higgin, C. P Sandberg, W. Wilson, C. D. Fox, and J. W. Barry, and Lieut.-Col. O'Connell, R.E.; a Watt Medal to Mr. E. Clark; a Telford Medal to Mr. W. J. McAlpine; Telford Premiums of books to Messrs. T. Login, A. Wilson, and W. Airy; and the Manby Premiums of Books to Mr. A. C. Howden. It was noted that Mr. E. Clarke had previously received a Telford Medal from the Institution.

With respect to the new building it was remarked, that as soon as it was determined to retain the existing site with the addition of the back part of an adjacent house, as recommended by the council, a lease was taken for 99 years of each of the two properties, for £450 per annum in the case of No. 25, Great George-street, with the option of purchase within ten years for £12,000, and in the case of the back part of No. 24, Great George-street for £208 13s. 4d. per annum, with a like power of making it freehold for £4,161 13s. 4d. It was mentioned that the two sums last named were the net amounts which would have to be paid, after making allowance for the very liberal gifts of two of the owners, viz., the entire of Mr. G. R, Stephenson's interest of one-third, and £503 in diminution of Mr. Bidder's interest, also of one-third.

At the same time the specifications and contract drawings for the works were prepared with alternative conditions: one for their completion and delivery in five months, so as to be ready for the opening of the present session, the other for their performance in eight months. Tenders were received from several eminent builders, and that of Messrs. Holland and Hannen being the lowest was accepted. That firm undertook to finish the building according to the architect's designs in five months for a sum of £11,650, and in eight months for a sum of £11,100. The contract was based on the first-named alternative, and had been duly fulfilled, in a substantial and satisfactory manner. In maturing the details of the plans of the new building several important modifications had been made, the principal being the addition of a newspaper and tea room on the ground floor, by which the area of accommodation for the general use of the members had been doubled, and the introduction of a glazed corridor on the first floor level—a further valuable concession granted by the owners of No. 24, Great George Street—by which it had been possible to provide four public entrances to the meeting-room, instead of two only as originally contemplated.

Time did not admit of the whole of the accounts in connection with the new building and its accessories being examined and settled prior to the close of the financial year of the institution on the 30th of November last, so as to be included in one statement of expenditure. But the accounts had since been collected, so that the council were enabled to state that, whereas the estimated outlay, including all contingent expenses of moving, furniture, &c., amounted to £16,810, they fully believed the actual cost, including some furniture not yet delivered, would not exceed £17,250. To meet the liabilities thus incurred, the council decided to dispose of, in the first instance, the building fund, being the accumulation of fees received from members and associates on joining the institution; next to realise the unconditional bequests; and lastly to sell so much as might be required of the investments made from time to time out of surplus income. The first two sources would, of course, be entirely exhausted but as far as the council could judge, when every liability was discharged, stock would still remain in hand of the nominal value of about £3,000 to provide for future contingencies. The Stephenson Bequest of £2,000, the Miller Bequest of £2,000, the Errington Bequest of £1,000, and the Locke Bequest of £2,000 would hereafter disappear from the accounts, but the names of these benefactors would be held in grateful remembrance as connected with the erection of the new building.

A notice had recently been served on the institution, that application was intended to be made to Parliament in the ensuing session for an Act, under the title of "Public Offices Concentration (Acquisition of Lands)," to empower the Commissioner of Her Majesty's Works and Public Buildings to acquire the property held by the Institution. The Council had, in reply to this notice, intimated their dissent to the proposed undertaking.

The council, having decided to institute an inquiry as to the systems of engineering education (other than military engineering) in different countries the cost to the students and to the respective Governments, and the effect, or presumed effect, of such preparatory training upon the profession, had addressed a circular letter to numerous technical establishments and private individuals abroad and at home. This circular had been fully responded to, and the result had been the receipt, quite recently, of a mass of materials which yet remained to be arranged, but which it was hoped would in due time be presented to the members. While on the subject reference was made to the munificent foundation, in perpetuity, by Mr. Joseph Whitworth, M. Inst. C.E., of Thirty-scholarships, of the annual value of £100 each, as to which a communication was brought forward from the council at one of the ordinary general meetings last sessions, and was adopted by acclamation.

During the past sessions 45 members and 105 associates had been elected, while the deceases, resignations and erasures together amounted to 34, leaving an effective increase of 116, or at the rate of 7·41 per cent. on the present number of members of all classes. This rate of increase had only been exceeded in the years 1865 and 1866, and had not been nearly equalled in any other year except 1867, when there was an increase of 7.02 per cent. There were on the books on the 30th of November last, 16 honorary members, 637 members, and 896 associates, making a total of 1,549, exclusive of students. The admissions to the class of students, which had only been in existence one session, had amounted to the same date to 133.

The deceases announced during the year had been :—Sir David Brewster and Lord Brougham, Honorary Members: George Rowdon Burnell, Alexander Gordon, Daniel Gallagher Grose, George Alfred Jermyn, Michael Lane, George Holsworthy Palmer, Thomas Rhodes and William Swinburne, Members; Henry Goulburn Anderson, Thomas Long Colley, Isaac Curran, Andrew Henderson, Peter Hogg, Frederic Cornell Reynolds, Robert Sharpe, Francis Adolphus Smart, Thomas Hitchin Smith, William Strode, William Swann and John Vaughan, Associates.

In reference to the financial position of the Institution, it was shown, by the abstract of accounts for the year ending the 30th of November, 1868, that the income proper, exclusive of all receipts from life compositions, building fund fees, and dividends of every kind, had amounted to £5,633 3s. 3d., while the ordinary disbursements had only been £3,667 4s. 8d., thus leaving a surplus of £1,965 18s. 7d. But when to this sum was added the above excluded items, still disregarding all trust monies, the surplus became £3,210 1s. 6d. In the early part of the session a sum of £1,250 was invested in the purchase of £1,944 1s. 8d. New Three per Cents. After it was decided to proceed with the New Building, Mrs. Locke's special donation of £200 was paid into the general account, and subsequently the treasurer received, from the Court of Chancery, the Locke Bequest of £2,000. As the works of the New Building proceeded, it became necessary tó dispose of stock to meet the Architect's certificates, and the amount of stock so sold had up to the present date produced £10,246 1s. 8d., with a loss between the purchase money and the sum realised of £168 6s. 10d.

The nominal value of the realised property belonging to, and under the charge of the Institution, consisted at the 30th of November last of :—I. General Funds, £12,056 1s. 8d., and II. Trust Funds, £12,119 15s. 11d., making, together with the cash balance of £1,232 14s. 10d., a total of £25,408 12s. 5d. as against £29,633 16s. 2d. at the date of the last report. This represents a decrease of £4,225 3s. 9d., but it was to be remarked that in the period referred to a sum of £9,711 16s. 10d. had been paid on account of the New Building.

In conclusion, the Council stated that they had much pleasure in submitting this narrative of their administration during a period of unusual responsibility, and they hoped their labours had been attended with advantage to the Institution.

The thanks of the Meeting were unanimously accorded to the President for his zealous efforts in the interests of the Institution; to the Vice-Presidents and the other Members and Associates of Council for their co-operation with the President, and their constant attendance at the meetings; to Mr. Bidder and to Mr. G. R. Stephenson for their very liberal contributions in aid of the New Building; to the Architect for the skill shown in the design of the Building, and to the Contractors for their energy in carrying it out; to Mr. Charles Manby, Honorary Secretary, and to Mr. James Forrest, Secretary, for the manner in which they had performed the duties of their offices; as also to the Auditors of the Accounts, and to the Scrutineers of the ballot for their services.

The following gentlemen were elected to fill the several offices on the Council for the ensuing year :—Charles Hutton Gregory, President; Joseph Cubitt, Thomas Elliot Harrison, Thomas Hawksley, and Charles Vignoles, Vice-Presidents; James Abernethy, William Henry Barlow, John Frederick Bateman, Joseph William Bazalgette, Nathaniel Beardmore, Frederick Joseph Bramwell, James Brunlees, George Willoughby Hemans, John Murray, and George Robert Stephenson, Members; M.-General Sir W. T. Denison, K.C.B., and Frederick Ransome, Associates.

## CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

### ON USING WATER IN THE EXCAVATION OF EARTHWORKS.

By H. Siccama, C.E., L.K. Inst. I.

For some time past the attention of divers engineers has been directed to the use that might be made of a flow of water, in excavating earthworks, and as a vehicle for the transport of material. As instances, I beg to mention a German method of tunnelling with a rotating iron shield, the excavation being performed by a flow of water, and on the Suez Canal works, where water is injected into the tubes or channels, conducting the material from the dredges to the deposit places, outside the dykes.

As I have applied the same principle myself, in practice, but on a somewhat larger scale, I will proceed to give a short account of my experience in the matter, hoping it will be of some use in similar cases, in India.

A few years ago I was entrusted with the construction of a division of a railroad, in the island of Java, running through a dense jungle for several miles; and amongst other works, relatively heavy, I had to excavate a cutting of about 60ft. deep, necessitating the removal of a cube of about 160,000 yards of hard clay, over a mean distance of 600 yards. The only means of transport at my command was by baskets, in the usual way, each containing a little less than 0.02 cube yard, or about half a cube foot. Under those circumstances I would not have been able to get more work out of each coolie, on an average, than half a cube yard per day. However, I could not dispose, at the utmost, over more than 1,500 men at that point, and even then it would have taken me, moving about 750 yards a day, about nine months to get through this cutting.

In this case I bethought myself of a method, much used by the natives in the island of Java in constructing their weirs, embankments, and roads, to save at least a large amount of transport.

The cutting, laying through a saddle between two hills, I dug three rows of catch-drains, one below the other, in contour round these, in which all the rain and well water was collected and conducted toward the top of the cutting, where it was received in a channel, running down along the centre line, towards the adjoining embankment that was to be, into a kind of reservoir, formed by faggot-hedges placed along the toe line of the bank.

The system of working now was as follows:—As soon as during a heavy shower or squall, or the regular monsoon rains, the water filled the catch-drains and ran down the centre channel, the coolies were placed along and on both sides of it, at distances of 3 to 5yds. apart, and a gang of men began to excavate at the top of the cutting, throwing the loose stuff into the channel, where it was soon mixed with water, and this mud ran down the incline with an occasional shove of a hoe to prevent obstructions. As the excavation at the top of proceeded, the men lower down also threw stuff in, and loosening the bottom of the channel occasionally kept it at its proper incline. The mud carried down at last came to rest in the reservoir, where it soon sank, and the water oosed away through the facines or faggots till the whole reservoir was filled or silted full, when another was made at the top of it, in the same way following the section of the embankment. This, built up in this way, was almost as solid as old ground, not showing any symptoms of settling or slipping.

I always endeavoured to keep the slopes in the cutting as steep as possible, slewing the washing channel from one side to the other as I got deeper, and keeping the discharge channel under the greatest possible inclination.

I found, practically, that 4 tons of water were quite sufficient to carry 1 cube yard of earth, measured in the cutting, down an incline of 1 in 50, for a distance of 800 or 1,000yds., with an occasional help down here and there.

The catch-drains enclosed an area of about 150 acres, and this afforded storm water enough to wash away about 120,000yds. in 4 months' time. The showers, however, falling irregularly, it often happened that I could only wash for a couple of hours per day, and sometimes only twice a week, never employing more than 300 men at a time, and often less than 200.

If we compare the respective costs of the two systems, you will perceive the great advantage in the one just described.

The expenses stand as follows. The centres of gravity of the two prisms under consideration are 600 yards apart:—

Transport by Baskets.

For one gang of 32 men, in clay (hard), for 9 hours.
5 getters (16 yards).
2 fillers.
1 at the tip.
24 carriers (going the full distance 4 times per hour).

| | |
|---|---|
| 32 men, at 10d. | 320d. |
| 1 moonshee or mandoor | 12d. |
| 8 new baskets, at 2d. | 16d. |
| For 16 cubic yards | 348d. |
| | or 1s. 9¾d. per yard. |

By Washing.

Using the storm water of 150 acres, which, at an average shower of ½ an inch, would give 9,000 tons of water, carrying off 2,250 yards of stuff, with—

| | | |
|---|---|---|
| At the top of the cutting | 20 men | |
| Along the channel | 80 ,, | |
| Watching the reservoir | 40 ,, | |
| For contour gutters, &c. | 30 ,, | |
| | 170 ,, | at 1s., 170s. |

| | |
|---|---|
| 170 coolies, at 1s. | 170s. |
| 6 foremen, at 1s. 2d. | 7s. |
| 400 yards of faggot hedge for reservoir, at 3d. | 100s. |
| For sluices, weirs, &c. | 50s. |
| | 327s. |
| Incidental | 33s. |
| For 2,250 cubic yards | 360s. |
| | or 1·92d. per cubic yard. |

This is an average price. Sometimes the charges came heavier, when showers came by night, and torches and fires were required to give light and to keep the tigers off. At other times, again, with daylight and plenty of water, cubes of 1,000 yards disappeared as if by magic, and some instances have been at which 5,000 yards were moved with only 300 coolies. I have not over-rated the rainfall, as I have known instances of 7 to 9in. falling in 24 hours, and of 4½in. to 5in. in two hours' time.

The whole amount of water used for this work is not known, as I had no regular notings of the daily downfall at this place. But we may compute it roughly, as it is known that the rainfall in India in the hills is, on an average, 110in., sometimes even 130in. a-year. I will say, that during the four months of washing above alluded to, we had a rainfall of 60in., we have an amount of 60 × 120 × 150, or 1,080,000 tons of water for the area of 150 acres. If one-third of this is allowed for absorption of the ground, we retain 720,000 tons for removing 120,000 cube yards of earth, being 6 tons per yard, or one-half more than wanted for an average condition.

I can now alone add, that the above-described system is also known and used under the name of *Colmatage*, and has been successfully applied on other sections of the same railway in Java, where a regular supply was to be procured from rivers, and a more regular organisation and progress of the works could be obtained.

## UNITED SERVICE INSTITUTION.

### IMPROVEMENTS IN SHIPS OF WAR.

At the meeting of this Institution held on the 19th ult., Captain E. A. Inglefield, R.N., read a paper explanatory of his new hydraulic steering apparatus, as being fitted in Her Majesty's ship *Achilles*. Having commenced by expressing his agreement with an opinion adduced some time ago that the one thing connected with a ship, which was at all times at the mercy of the waves, was the steering apparatus, Captain Inglefield proceeded to say that the hydrostatic hydraulic system, in which water was the motive power, was superior to the steam hydraulic system, inasmuch as in those ships in which the steering apparatus was constructed after the latter plan a want of uniformity of action was frequently perceptible. When steam was employed, considerable time was lost in preparing the engines to act as motive power, and the waste of labour was also considerable. The new apparatus could be worked from the pilot house, or from the lower or middle deck, and the quantity of water employed for working it would not be more than what would be necessary for clearing the bilges. He maintained, then, that his apparatus was to be recommended for the reasons that the motive power necessary for its direction was always available, and the time within which it could be put in action was inconsiderable. The construction of the apparatus cannot, be easily understood without the aid of diagrams; it may be added, however, that the object of Captain Inglefield's paper was to prove the efficiency of a steering apparatus in which steam-engines would not form part of the system. At the conclusion of Captain Inglefield's address, and the discussion which followed, Lieutenant A. H. Gillmore, R.N., explained the properties of his new expanding plug for stopping shotholes in the sides of vessels. This is a most ingenious contrivance and its invention can scarcely fail to excite considerable interest among naval officers, especially as regards its application to ironclad ships. The plug, as it is most unhappily called, represents the shape of a closed parasol before it is inserted in a shothole. When it has been thrust out to the necessary length outside the ship's side, it is made to expand by the action of a lever, and then assumes the shape of a raised parasol or a small umbrella. It is then made tight to the ship's side, and the inventor asserts that little, if any, leakage can occur if the plug be properly fitted. A plug 4½in. in diameter when closed will cover a hole 16in. in diameter when expanded. This description of plug can, as will be readily perceived, be only used when shot or shell penetrates through and through armour-plates. Lieutenant Gilmore has provided another apparatus for stopping holes when the shot or shell has only partly penetrated the ship's side. This consists of a lever working on the outside of the ship on a sort of pivot, at the end of which is a round plate, which can be directed to the spot where the armour-plate has been struck. It was apparent at the meeting that the apparatus exhibited were capable of considerable improvement but, as we have intimated, the subjects adduced are worthy of all the attention which can be bestowed upon them, as it is obvious that the smashing of the armour-plates of a vessel must considerably diminish its efficiency as a fighting engine, and that the danger of her being sunk by the rush of water into her hold is considerably greater than in the case of a wooden ship. Lieutenant Gilmore also exhibited what he called an expanding sponge, the expansion being caused by the action of the stick attached to it. This stick being pressed with a certain force, an expansion of some 18in. is procured on the whole circumference of the sponge. He also explained a diagram on which was indicated the mode of constructing a vessel to be sent over places where torpedoes are known to exist, or where their existence is suspected. The ship is to be made in cells so that if one or more of the cells be blown up the remaining compartments would retain their floating power. Lieutenant Gilmore thought that the plating of the vessel should not be very thick, inasmuch as if it were so the danger of the whole structure being blown up at once would be much greater than if the plates were thin. Captain Inglefield said that he had often felt the necessity of such a vessel as that proposed by Lieutenant Gilmore. At present the explosion of torpedoes resulted as a rule in the total destruction of the ships against which their action was directed. He was sure that if a vessel were built on Lieutenant Gilmore's system it would be a most valuable addition to the navy, and he felt confident that volunteers would be always forthcoming from among our sailors to man such a vessel. Votes of thanks were accorded to Captain Inglefied and Lieutenant Gilmore for their interesting addresses, after which the proceedings terminated.

## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

### CHIEF ENGINEER'S MONTHLY REPORT.

The ordinary monthly meeting of the executive committee of this association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, October 27th, 1868, William Fairbairn, Esq., C.E., F.R.S., LL.D., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 227 visits of inspection have been made, and 518 boilers examined, 389 externally, 3 internally, 2 in the flues, and 124 entirely, while, in addition, 6 have been tested by hydraulic pressure. In these boilers 85 defects have been discovered, 5 of them being dangerous.

Tabular Statement of Defects, Omissions, &c.

Met with in the Boilers examined from September 26th, 1868, to October 23rd, 1868, inclusive.

| Description. | Number of Cases met with. | | |
|---|---|---|---|
| | Dangerous. | Ordinary. | Total. |
| **Defects in Boiler.** | | | |
| Furnaces out of Shape | ... | 1 | 1 |
| Fracture | ... | 12 | 12 |
| Blistered Plates | ... | 2 | 2 |
| Corrosion—Internal | 1 | 9 | 10 |
| Ditto External | 2 | 7 | 9 |
| Grooving—Internal | ... | 7 | 7 |
| Ditto External | ... | 1 | 1 |
| Total Number of Defects in Boiler ... | 3 | 39 | 42 |
| **Defective Fittings.** | | | |
| Feed Apparatus out of order | ... | 2 | 2 |
| Water Gauges ditto | 1 | 6 | 7 |
| Blow-out Apparatus ditto | ... | 3 | 3 |
| Fusible Plugs ditto | ... | ... | ... |
| Safety Valves ditto | 1 | 4 | 5 |
| Pressure Gauges ditto | ... | 6 | 6 |
| Total Number of Defective Fittings ... | 2 | 21 | 23 |
| **Omissions.** | | | |
| Boilers without Glass Water Gauges | ... | ... | ... |
| Ditto Safety Valves | ... | ... | ... |
| Ditto Pressure Gauges | ... | ... | ... |
| Ditto Blow-out Apparatus | ... | 2 | 2 |
| Ditto Feed back pressure valves | ... | 16 | 16 |
| Total Number of Omissions | ... | 18 | 18 |
| Cases of Over Pressure | ... | 2 | 2 |
| Cases of Deficiency of Water | ... | ... | ... |
| Gross Total | 5 | 80 | 85 |

During the past month 5 explosions have occurred, by which 16 persons have been killed, and 9 others injured. A great fatality has recently taken place at Ironworks, 4 explosions having occurred in about 6 weeks, resulting in as many as 23 deaths. Not one of the boilers in question was under the inspection of this association. The following is the monthly tabular statement :—

### TABULAR STATEMENT OF EXPLOSIONS,

From September 26th, 1868, to October 23rd, 1868, inclusive.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 36 | Sept. 28 | Vertical Furnace, Ironworks ............ | 13 | 2 | 15 |
| 37 | Oct. 2 | Vertical Furnace, Ironworks ............ | 2 | 0 | 2 |
| 38 | Oct. 12 | Description not yet fully ascertained, Colliery.................. | 1 | 1 | 2 |
| 39 | Oct. 16 | Feed-Water Heater, or Economiser, Cotton Mill ............ | 0 | 0 | 0 |
| 40 | Oct. 19 | Self-feeding Kitchen Boiler, Hotel .................. | 0 | 6 | 6 |
| | | Total.................. | 16 | 9 | 25 |

### FEED-WATER HEATER EXPLOSIONS.

No. 39 explosion, by which fortunately no one was either killed or seriously injured, occurred to a feed-water heater at a cotton mill, at about seven o'clock on the morning of Friday, October 16th.

It has been generally thought that feed-water heaters were incapable of explosion, since, if one of the pipes should burst, it would merely relieve the pressure, and that no danger whatever was to be anticipated from their use. The fact, therefore, of a water heater having exploded with great violence, and being attended with considerable destruction of property, has been regarded with a good deal of interest, and deserves full investigation.[*]

The feed-water heater or economiser was of the description very generally employed in this locality. It was placed in the main flue between the boilers and the chimney, so as to utilise the waste heat passing off with the gases. It consisted of about 240 vertical cast iron pipes arranged in 30 rows of 8 each. The length of three pipes was 10ft., their internal diameter 4in., and the thickness of metal three-eighths of an inch. The economiser was fitted with a 3in. safety-valve, while the blowing-off pressure of the boilers to which it was connected was between 60lb. and 65lb.

Fig. 1.

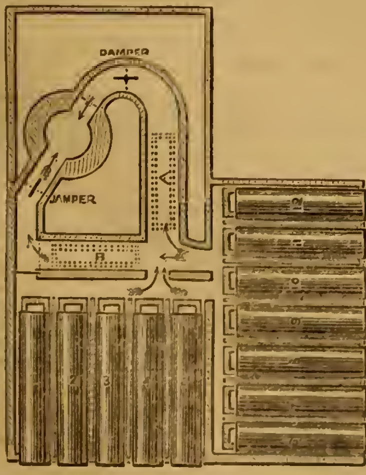
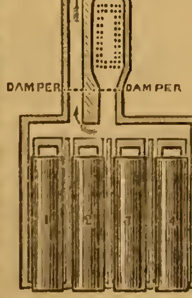


Fig. 2.



This was not the only feed heater on the works. There were two series of boilers connected to the same chimney, and two economisers, the relative position and arrangement of which will be better understood on reference to the accompanying plan, Fig. 1, in which the exploded economiser is marked A, and the other one B. It is important to observe that the flues for each economiser were not distinct the one from the other, but so arranged that both economisers were open to both series of boilers, so that the gases were at liberty to pass entirely through one economiser or entirely through the other, or through both combined. This is a point which must not be overlooked in this investigation.

On the occurrence of the explosion the economiser was torn from its seat and broken into hundreds of pieces, which were scattered to various distances of about 30ft. or 40ft. At the same time the fire doors of all the boilers but No. 6, which was the most distant from the economiser, were violently blown open, and one of the stokers burnt by the flames leaping out upon him, while another man, who was firing No. 4 boiler, started backwards on finding the flames burst out, but before he had retreated many feet, was blown back on the top of the coal-heap behind him. Besides this, the boiler-house roof was considerably damaged, the side of the engine-house blown down, and the brickwork surrounding the economiser levelled to the ground, while the main flue to the chimney was ripped open, the crown of some of the other flues lifted, one of the boilers moved slightly forward, just sufficiently so to break the steam pipe joint, and the brickwork covering on the top of the boilers marked Nos. 1, 2, 3, 4, 5 loosened, either by the shock or other consequence of the explosion, in addition to which many panes of glass in the mill were broken, and a window of one of the upper storeys bulged outward. Altogether considerable havoc was done, and, regarding the amount of masonry dislodged, and the shower of cast iron pipes and broken fragments that must have fallen, it is surprising that no lives were lost.

With regard to the cause of the disaster,—it has been attributed rather to the explosion of coal-gas, accumulated in one of the flues, than to the bursting of the economiser from internal pressure. This question is one of considerable interest, and on which a good deal of discussion has arisen. Those who attribute the disaster to the explosion of coal-gas, conclude that in consequence of the current through the economiser being checked by the closing of the damper between it and the chimney, an accumulation of gas thrown off from the fires took place within the flue, the gas being either carbonic oxide, or carburetted hydrogen, or possibly a mixture of the two, which, combined with air admitted through the furnace doors, or passed unconsumed through the bars, which is always the case to a great extent,[*] would form a very explosive compound, needing only to be ignited by a red-hot spark to cause an explosion. It will be seen, on consulting the plan, that the furnaces in No. 4 boiler, which the man previously referred to was in the act of firing at the moment of explosion, and from which he was blown, were situated precisely in line with the chamber of the shattered economiser, so that it is thought that his stirring up the fires kindled the spark which led to the explosion, and thus that the train of argument is complete. Parties engaged in the construction of these economisers say that this view is supported by experience, and that other cases of explosion from the ignition of coal-gas have come under their notice, though by no means so violent or destructive as the present one.

On visiting the scene of the catastrophe a few days after the explosion had occurred, when the bewilderment consequent upon it had somewhat died away, and there had been time to correct mistaken impressions and conflicting statements, I gathered that the following were the circumstances under which the explosion occurred, a consideration of which may be of assistance in determining whether the explosion was one of coal-gas or steam.

It appears that on the afternoon of Thursday, which was the day preceding the explosion, a leak was found to have sprung in one of the economisers, which prevented the proper water level being maintained in the boilers. As it was not known which of the economisers was at fault, both of them were shut off, the valves or taps between them and the feed pump, as well as those between them and the boilers, being closed, so that each economiser became completely isolated. Neither of the dampers between the economiser and the chimney were lowered, but the gases allowed to pass through the economisers just as before. In addition to the ordinary dampers, there was a swivel damper between each economiser and the chimney, which was operated upon by the pressure of steam in the boilers, and closed when the steam rose to blowing-off point, so as to prevent unnecessary waste. At the moment of explosion, the steam pressure was very near to blowing-off point, so that as the swivel damper in the flue of the exploded economiser worked more freely than the other, it is not improbable that it was closed, or nearly so, at the time, and thus that the chamber of the exploded economiser was rendered almost a sealed one, as previously supposed, while the current passed through the other. To prevent an accumulation of internal pressure under the extraordinary circumstances of keeping the economisers bottled up while all the fires were hard at work, the lever of the safety-valve on each economiser was raised and blocked up with a bolt, in order that they might be worked on at atmospheric pressure only. The levers of the safety-valves were found to be blocked up in this way after the explosion had occurred, while those in charge stated they had seen steam escaping through the valves but a short time before the explosion, so that they must have been free. To put the matter beyond all doubt, however, I thought it best to have the cover of both safety-valve boxes removed, and, in doing this, found that the levers and spindles could be lifted without stirring the valves, since they were altogether disconnected, while, although the valve itself on the economiser that had not exploded was perfectly free, that on the other was firmly locked in its seat by a coat of incrustation, and required several smart blows on its underside from a hammer to liberate it. As there was no connection between the two economisers, the idea, therefore, that it was impossible for there to be any pressure above the atmosphere within the exploded one, was quite a mistake; and, instead of this, there may have been one of some 500lb. or 600lb., from the temperature of the gases in the flue. It should be borne in mind that as the explosion occurred at seven o'clock in the morning, it took place just when there would have been time for the economiser to be thoroughly heated up, so that these circumstances would at once have accounted for the explosion had the rents and flight of the fragments been such as appeared due to internal pressure. Internal pressure, however, will, under ordinary circumstances, burst a cylinder open longitudinally, since the tendency to rend in that direction is precisely double that to rend in the other, whatever may be the diameter of the cylinder or pressure of steam. On examining the fractured pipes, however, none could be discovered that had rent longitudinally, but all that could be seen had been broken off transversely about midway in their length, as if from an external blow rather than from internal pressure. Added to this, all the fragments were lifted from their original seat, whereas internal pressure, while it would have blown the upper portion into the air, would have tended to drive the lower one into the ground. Thus, the general development of the explosion scarcely appeared to confirm the view that the economiser had burst from internal pressure, though it is difficult to predicate minutely what the order of results would be in a series of cast iron pipes in the event of a rupture from some 500lb. or 600lb. internal steam pressure. It is stated, however, that boilers of very similar construction, consisting of a number of cast iron pipes, have been severely fired with the safety-valve locked down for the purpose of experiment, when it has been found that only one of the pipes has burst, which has let off the pressure, so that no explosion could be produced.

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[*] This is not a peculiar instance. Another water heater exploded a short time since, particulars of which cannot be given on the present occasion, on account of the length to which this report has already extended.

[*] Dr. R. Angus Smith, in experimenting on the gases passing off from several large chimneys, found that much more free oxygen passed off to waste than was consumed in the furnaces.

Under these circumstances I thought it advisable to consult Dr. R. Angus Smith, F.R.S., F.C.S., &c., on the chemical view of the subject, and to take his opinion upon the possibility of an explosion occurring from coal-gas under the special circumstances of the case, and also of its effecting the destruction of property that occurred. With this view I paid a second visit to the scene of the explosion, in company with Dr. Smith. After making an examination of the ruins, Dr. Smith came to the conclusion that both the explosion and its results were possible from the ignition of coal-gas accumulated in the flues, but it may be well to give the following extract from a communication received from him on the subject. Dr. Smith says:—"Explosive gases are formed by simply mixing gases and vapours from coal with air. Indeed, every fire is making gases which explode when heated with air, so that the question arises why are we not blown up daily? The answer is—because the currents of air are so constant, penetrating, and intrusive that they follow the gases, and thus a constant and steady fire is the consequence, instead of a hasty and violent one. Every furnace, however, especially if a large one, becomes to some extent a gas retort, and generates exactly the same products, though burning them more or less. Stop the draught and gas is made. Let air enter and an explosive mixture is formed at once.* Thus there is no difficulty in accounting for the circumstances under examination by an explosion of gas. The long furnaces, with the impeded draught and hot flue, were capable of forming gases abundantly powerful to produce all the effects developed by the explosion under consideration. In support of this I may mention that, a short time since, I happened to enter works a day or two after the occurrence of two explosions, which could be accounted for in no other way than that just mentioned. The wonder rather is that such explosions occur so seldom."

Notwithstanding that it may be quite possible that the explosion arose from the ignition of coal-gas, it scarcely appears to admit of demonstration that it actually took place from this cause. If it did, it may be asked, why had not the catastrophe occurred long before, as the swivel dampers had been at work for months, constantly opening and closing as the steam rose and fell, and there was nothing unusual in the condition of the flues excepting that they were flooded with about a foot of water, which had escaped from the economiser? Beside this, the fact that the safety-valve was free in the economiser that did not explode and locked fast in the one that did, while the explosion occurred at seven o'clock in the morning, just an hour after starting, when the economiser would have had time to be well heated up, and an internal pressure accumulated, are strong arguments in favour of the explosion being due to steam pressure. Thus there appears to be considerable probability in favour of both views, though scarcely sufficient evidence to decide positively on either one, and to justify a decided opinion as to whether the explosion arose from coal-gas or internal steam pressure.

The object of these inquiries, however, is to show how to avoid similar disasters in future, and it is thought that this end will be attained by pointing out such precautions to be adopted in the construction and management of these economisers as will guard against their explosion either by coal-gas on the one hand, or by steam pressure on the other; and with this view the two following recommendations are given:—

To prevent the explosion of economisers from internal pressure, they should be fitted with a thoroughly reliable safety-valve, not liable to derangement by incrustation. No valves would be more suitable than those of external dead-weight pendulous construction, which are made without levers, fangs, or spindles to jam fast, and instead of being boxed in out of sight, are entirely open to view. Valves of this description are in very general use on steam boilers, and hundreds of them, under the inspection of this association, have been satisfactorily at work for years, so that their adoption may be confidently recommended.

To prevent explosions from coal-gas, there should be no chambers in which the gas can lurk. The arrangement in the present instance was eminently peculiar, and most conveniently contrived for courting an accumulation of gas, so that it would be advisable to convert the two economisers into one, and have but one chamber instead of two. In some instances the ordinary reserve flue might become a source of danger if closed by a damper near to the chimney, but this would be avoided by closing the damper at its entrance, so that there may be no void chamber in which the gases may accumulate. For the same reason, when the reserve flue is in use, the economiser should be cut off by a damper at the entrance, and not at the chimney.

This will be more readily understood on a consultation of Fig. 2, in which the reserve flue is shown in full work, and the economiser stopped off, with the damper between it and the chimney closed, and the one at the entrance opened. Under these circumstances there will be little or no current through the chamber, and thus an accumulation of gas might settle in it and become ignited by sparks from boilers Nos. 2 and 3, which are directly opposite to it, very much as in the case of the explosion just reported above. It will be seen that the danger of this would be averted by closing the damper at the entrance to the chamber of the economiser, and also that the damper in the reserve flue is in a much better position close to the boilers than at the chimney.

It will be well for members to overhaul their economiser arrangements, and see that they do not admit of such combinations as those illustrated in this plan, and, if necessary, to have their dampers altered accordingly.

If these simple precautions are adopted, it is thought that well-made feed-water heaters or economisers can be worked on in safety, and that the confidence so long reposed in them may be restored.

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The last ordinary monthly meeting of the executive committee of this association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, January 12th, 1869, William Fairnbairn, Esq., C.E., F.R.S., LL.D., &c., &c., President, in the chair, when Mr. L. E. Fletcher, Chief Engineer, presented his report, of which the following is an abstract:—

During the past month 373 visits of inspection have been made, and 800 boilers examined. Of this number of boiler examinations, 574 have been external, 14 internal, 8 in the flues, and 204 entire, while, in addition, 9 boilers, have been tested by hydraulic pressure. In these boilers 125 defects have been discovered, 11 of them being dangerous. Furnaces out of shape, 3,—2 dangerous; fractures, 15; blistered plates, 7,—1 dangerous; internal corrosion, 19,—2 dangerous; external ditto, 17,—1 dangerous; internal grooving, 17; external ditto, 3; feed apparatus out of order, 4; water guages ditto, 6,—1 dangerous; blow-out apparatus ditto, 12; safety-valves ditto, 3; pressure gauges ditto, 7; boilers without glass water gauges, 4,—dangerous; without pressure gauges, 1; without blow-out apparatus, 2; without feed back pressure valves, 5.

### Explosions.

On the present occasion I have two explosions to report, by which four persons were killed and three others injured. Not one of these explosions occurred to boilers under the inspection of this association. The following is the monthly tabular statement:—

### Tabular Statement of Explosions,

From November 21st, 1868, to December 31st, 1868, inclusive.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 42 | Dec. 2 | Vertical, Internally fired ...... | 0 | 1 | 1 |
| 43 | Dec. 11 | Vertical Marine, Internally fired ...... | 4 | 2 | 6 |
| | | Total ................ | 4 | 3 | 7 |

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* From these remarks of Dr. Smith it would appear that there is danger from irregular and intermittent currents in furnace flues, since where they exist gas may be berated at one time and air mixed with it at another, and thus an explosive mixture ormed, so that the effect of the intermittent action of lively swivel dampers upon large [illegible] fires is a point worthy of investigation.

## REPORT OF THE TRIALS AT WIGAN OF THE SOUTH LANCASHIRE AND CHESHIRE STEAM COALS.—*Continued from page 21.*

| | Index No. of Trial. | Vacuum in Chimney expressed in inches of Water | Vacuum in Flame Box expressed in inches of Water | Temperature of Feed Water | Temperature of Air | Thickness of Fires | Lbs. of Coal added per Stoke | Average interval in minutes between stoking each furnace | Length of Trial. | Gross weight of Water in lbs. evaporated during trial | Gross weight of Coals in lbs. burnt to evaporate preceding | SMOKE DURING TRIAL | | | ASH AND CLINKER. | | WATER EVAPORATED AT 100° | | COAL BURNT. | | ECONOMIC VALUE. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Gross No. of minutes of Very Light | Gross No. of minutes of Brown | Gross No. of minutes of Black | Per centage of Ash | Per centage of Clinker | Lbs. per hour | Lbs. per hour per Sq. Ft. of Fire Grate | Lbs. per hour | Lbs. per hour per Sq. Ft. of Fire Grate | Cubic Feet of Water at 100° evaporated per hour | Lbs. of Water at 100° evaporated per lb. of Coal |
| | | In. | In. | | | In. | | | h.m. | | | | | | | | | | | | | |
| Hindley Yard Coal ......... | 1 | $\frac{3}{8}$ full | $\frac{1}{4}$ full | 58° | 47° | 14 | 29·4 | 13·5 | 3.51 | 10677 | 1000 | 0 | 0 | 0 | 2·0 | 2·3 | 2885 | 280 | 260 | 25 | 45·15 | 11·10 |
| | 1*a* | $\frac{3}{8}$ full | $\frac{1}{4}$ full | 57° | 46° | 14 | 32·2 | 14·9 | 3.51 | 10677 | 1000 | 2 | 0 | 0 | 2·2 | 2·5 | 2887 | 280 | 260 | 25 | 46·19 | 11·11 |
| | | | | | | | | | | | | | | | | | | | | Mean | 46·17 | 11·10 |
| Worsley Top 4ft. Coal ... | 1 | $\frac{3}{8}$ | $\frac{5}{16}$ | 55° | 71° | 14 | 32·2 | 11·6 | 3.0 | 8855 | 1000 | 12 | 0 | 0 | 2·0 | 2·4 | 3078 | 298 | 333 | 32 | 49·24 | 9·23 |
| | 1*a* | $\frac{3}{8}$ full | $\frac{5}{16}$ | 57° | 64° | 14 | 29·4 | 11·2 | 3.12 | 9180 | 1006 | 14 | 0 | 0 | 1·4 | 2·2 | 2986 | 290 | 313 | 30 | 47·76 | 9·55 |
| | | | | | | | | | | | | | | | | | | | | Mean | 48·50 | 9·39 |
| Upper Crumbouke Coal... | 1 | $\frac{7}{16}$ | $\frac{5}{16}$ | 43° | 53° | 14 | 38·4 | 15·4 | 3.21 | 9635 | 1000 | 20 | 0 | 0 | 2·6 | 2·4 | 3035 | 294 | 299 | 29 | 48·56 | 10·16 |
| | 1*a* | $\frac{3}{8}$ full | $\frac{1}{4}$ full | 46° | 53° | 14 | 38·4 | 15·6 | 3.24 | 9635 | 1000 | 16 | 0 | 0 | 2·7 | 2·3 | 2982 | 289 | 294 | 29 | 47·71 | 10·13 |
| | | | | | | | | | | | | | | | | | | | | Mean | 48·13 | 10·14 |
| Lower Crumbouke Coal... | 1 | $\frac{3}{8}$ full | $\frac{5}{16}$ | 38° | 44° | 14 | 31·2 | 13·6 | 3.39 | 10417 | 1000 | 6 | 0 | 0 | 1·6 | 1·4 | 3027 | 294 | 274 | 27 | 48·43 | 11·04 |
| | 1*a* | $\frac{3}{8}$ full | $\frac{5}{16}$ | 42° | 53° | 14 | 34·4 | 15·3 | 3.42 | 10677 | 1000 | 8 | 0 | 0 | 1·8 | 1·7 | 3048 | 296 | 270 | 26 | 48·77 | 11·27 |
| | | | | | | | | | | | | | | | | | | | | Mean | 48·60 | 11·15 |
| Upper Three Yards Coal... | 1 | $\frac{3}{8}$ full | $\frac{1}{4}$ full | 47° | 50° | 14 | 38·4 | 16·3 | 3.33 | 9896 | 1000 | 16 | 0 | 0 | 1·4 | 0·9 | 2930 | 284 | 282 | 27 | 46·88 | 10·40 |
| | 1*a* | $\frac{3}{8}$ | $\frac{1}{4}$ | 46° | 47° | 14 | 38·4 | 16·8 | 3.39 | 9896 | 1000 | 8 | 0 | 0 | 1·5 | 0·8 | 2853 | 277 | 274 | 27 | 45·64 | 10·41 |
| | | | | | | | | | | | | | | | | | | | | Mean | 46·26 | 10·40 |
| Six Feet Rams Coal ...... | 1 | $\frac{7}{16}$ | $\frac{5}{16}$ bare | 51° | 55° | 14 | 34·4 | 14·5 | 3.30 | 9635 | 1000 | 7 | 0 | 0 | 6·2 | 2·6 | 2883 | 280 | 286 | 28 | 46·12 | 10·08 |
| | 1*a* | $\frac{7}{16}$ full | $\frac{5}{16}$ | 49° | 45° | 14 | 37·0 | 17·1 | 3.51 | 9765 | 1000 | 8 | 0 | 0 | 4·2 | 2·1 | 2661 | 258 | 260 | 25 | 42·58 | 10·24 |
| | | | | | | | | | | | | | | | | | | | | Mean | 44·35 | 10·16 |
| Great Seven Feet Coal ... | 1 | $\frac{3}{8}$ full | $\frac{5}{16}$ bare | 38° | 40° | 14 | 38·4 | 15·6 | 3.24 | 9896 | 1000 | 21 | 0 | 0 | 1·1 | 0·6 | 3086 | 299 | 294 | 29 | 49·38 | 10·49 |
| | 1*a* | $\frac{3}{8}$ bare | $\frac{5}{16}$ bare | 38° | 35° | 14 | 37·0 | 14·0 | 3.9 | 9896 | 1000 | 18 | 0 | 0 | 1·0 | 0·7 | 3331 | 321 | 317 | 31 | 53·30 | 10·49 |
| | | | | | | | | | | | | | | | | | | | | Mean | 51·34 | 10·49 |
| Blackrod Yard Coal ...... | 1 | $\frac{3}{8}$ full | $\frac{1}{4}$ full | 37° | 37° | 14 | 30·3 | 13·8 | 3.48 | 10156 | 1000 | 2 | 0 | 0 | 1·6 | 1·5 | 2837 | 275 | 263 | 26 | 45·39 | 10·78 |
| | 1*a* | $\frac{3}{8}$ | $\frac{5}{16}$ | 37° | 38° | 14 | 34·4 | 16·1 | 3.54 | 10417 | 1000 | 17 | 0 | 0 | 1·7 | 1·4 | 2835 | 275 | 256 | 25 | 45·36 | 11·05 |
| | | | | | | | | | | | | | | | | | | | | Mean | 45·37 | 10·91 |
| Pemberton Four Feet Coal | 1 | $\frac{7}{16}$ | $\frac{5}{16}$ | 47° | 37° | 14 | 34·4 | 13·5 | 3.9 | 9635 | 1000 | 11 | 0 | 0 | 1·6 | 1·6 | 3215 | 312 | 317 | 31 | 51·44 | 10·12 |
| | 1*a* | $\frac{7}{16}$ | $\frac{1}{4}$ full | 45° | 37° | 14 | 32·2 | 12·1 | 3.8 | 9635 | 1000 | 8 | 0 | 0 | 1·5 | 1·6 | 3239 | 314 | 319 | 31 | 51·82 | 10·14 |
| | | | | | | | | | | | | | | | | | | | | Mean | 51·63 | 10·13 |
| Haigh or Arley Yard Coal | 1 | $\frac{3}{8}$ | $\frac{1}{4}$ full | 45° | 52° | 14 | 32·2 | 14·2 | 3.42 | 10677 | 1000 | 4 | 0 | 0 | 1·6 | 1·6 | 3039 | 295 | 270 | 26 | 48·63 | 11·24 |
| | 1*a* | $\frac{3}{8}$ full | $\frac{1}{4}$ full | 45° | 44° | 14 | 31·2 | 14·6 | 3.54 | 10677 | 1000 | 0 | 0 | 0 | 1·5 | 1·6 | 2884 | 280 | 256 | 25 | 46·13 | 11·24 |
| | | | | | | | | | | | | | | | | | | | | Mean | 47·38 | 11·24 |
| Furnace Mine Coal......... | 1 | $\frac{3}{8}$ | $\frac{1}{4}$ | 44° | 50° | 14 | 31·2 | 12·2 | 3.16 | 8855 | 1000 | 6 | 0 | 0 | 7·0 | 2·8 | 2858 | 277 | 306 | 30 | 45·73 | 9·33 |
| | 1*a* | $\frac{3}{8}$ | $\frac{1}{4}$ full | 45° | 57° | 14 | 30·3 | 12·5 | 3.27 | 8855 | 1000 | 4 | 0 | 0 | 6·8 | 3·1 | 3703 | 262 | 290 | 28 | 43·25 | 9·32 |
| | | | | | | | | | | | | | | | | | | | | Mean | 44·49 | 9·32 |
| Bickerstaffe Four Feet Coal | 1 | $\frac{3}{8}$ full | $\frac{5}{16}$ | 41° | 20° | 14 | 33·3 | 13·2 | 3.18 | 9375 | 1000 | 0 | 0 | 0 | 1·4 | 0·6 | 3004 | 291 | 303 | 29 | 48·06 | 9·91 |
| | 1*a* | $\frac{3}{8}$ | $\frac{1}{4}$ | 36° | 33° | 14 | 31·2 | 14·0 | 3.45 | 9375 | 1000 | 0 | 0 | 0 | 1·5 | 0·6 | 2656 | 258 | 267 | 26 | 42·50 | 9·96 |
| | | | | | | | | | | | | | | | | | | | | Mean | 45·28 | 9·93 |
| Rushy Park and Little Delf Coals, Mixed ...... | 1 | $\frac{7}{16}$ | $\frac{5}{16}$ | 46° | 50° | 14 | 38·4 | 15·0 | 3.15 | 9635 | 1000 | 12 | 0 | 0 | 1·6 | 1·5 | 3120 | 303 | 308 | 30 | 49·91 | 10·13 |
| | 1*a* | $\frac{7}{16}$ | $\frac{1}{4}$ full | 47° | 52° | 14 | 37·0 | 14·0 | 3.9 | 9635 | 1000 | 16 | 0 | 0 | 1·4 | 1·6 | 3216 | 312 | 317 | 31 | 51·44 | 10·12 |
| | | | | | | | | | | | | | | | | | | | | Mean | 50·67 | 10·12 |
| Ince Mixed Coal............ | 1 | $\frac{3}{8}$ | $\frac{1}{4}$ full | 47° | 44° | 14 | 37·0 | 14·8 | 3.20 | 9375 | 1000 | 4 | 0 | 0 | 1·8 | 2·1 | 2957 | 287 | 300 | 29 | 47·30 | 9·85 |
| | 1*a* | $\frac{3}{8}$ full | $\frac{1}{4}$ full | 46° | 40° | 14 | 37·0 | 15·3 | 3.27 | 9375 | 1000 | 1 | 0 | 0 | 1·6 | 2·0 | 2850 | 279 | 290 | 28 | 45·74 | 9·86 |
| | | | | | | | | | | | | | | | | | | | | Mean | 46·52 | 9·85 |
| Arley Mine Coal............ | 1 | $\frac{7}{16}$ bare | $\frac{5}{16}$ bare | 40° | 36 | 14 | 33·3 | 16·0 | 4.0 | 9505 | 1000 | 0 | 0 | 0 | 2·0 | 1·6 | 2515 | 244 | 250 | 24 | 40·24 | 10·06 |
| | 1*a* | $\frac{7}{16}$ bare | $\frac{5}{16}$ fnll | 38° | 31° | 14 | 31·2 | 14·3 | 3.59 | 10677 | 1000 | 2 | 0 | 0 | 1·9 | 1·8 | 2954 | 286 | 261 | 25 | 47·26 | 11·32 |
| | 1*b* | $\frac{7}{16}$ bare | $\frac{5}{16}$ bare | 35 | 34° | 14 | 33·3 | 16·2 | 4.3 | 10677 | 1000 | 3 | 0 | 0 | 1·9 | 1·8 | 2804 | 272 | 247 | 24 | 44·86 | 11·35 |
| | | | | | | | | | | | | | | | | | | | | Mean | 44·12 | 10·92 |

## SOCIETY OF ENGINEERS.

### ON THE APPLICATION OF STEAM TO THE CULTIVATION OF THE SOIL.

By Baldwin Latham.

(*Continued from page* 17.)

### Class 1.—Traction Engines.

The earliest invention, of which any record has been kept, of the principle that was to be adopted in applying steam for the cultivation of the soil, is set forth in the invention of Richard Lovell Edgeworth, in February, 1770; and his invention is stated to consist "in making portable railways to wheel carriages, so that several pieces of wood are connected to the carriage, which it moves in regular succession, in such a manner that a sufficient length of railing is constantly at rest for the wheels to roll upon, and that, when the wheels have nearly approached the extremity of this part of the railway, their motion shall lay down a fresh length of rail in front, the weight of which in its descent shall assist in raising such part of the rail as the wheels have already passed over; and thus the pieces of wood which are taken up in the rear are in succession laid in the front, so as to furnish constantly a railway for the wheels to roll upon." This description of the invention unfortunately is not accompanied with any drawing to illustrate its nature; and, therefore, it may be taken to include the principle applied so successfully by Boydell, which will be described hereafter; or it may have reference to the application of an endless railway, similar to that described by Sir John Scott Lillie. It does not appear that the author of this invention was even able to reduce the principle he propounded to practice, for we find him stating that the term of his patent expired without his "being able to unite to my satisfaction in this machine's strength with sufficient lightness, and with regular motion, so as to obtain the advantages I proposed.

In the year 1808 John Dumbell procured a patent for a machine that was to be used for agricultural purposes. This machine is intended to be worked by steam or heated vapour acting on a series of vanes fixed on a metal shaft within the cylinder, and from which motion was transmitted to the wheels of the carriage, which, in its turn, was intended to drag along a series of ploughs.

In 1810, Major Pratt produced a series of inventions having reference to the application of steam to the cultivation of the soil. One portion of his invention relates to a machine which was to be moved onward "by means of endless chains, extended horizontally over chain wheels," driven by steam power. "The endless chains having arms jointed thereto, carrying transverse bars provided with spikes," which take hold of the ground and draw the machines along. The inventor also refers to the means of substituting ploughs for the spikes attached to the endless chains of the machine. Another portion of Pratt's invention, and certainly the part worthy of the most consideration, will be referred to under its proper class.

In 1812 William Chapman, and Edmund Walter Chapman, invented a mode of applying traction force to machines, the principle of which has at various times been recommended for adoption in steam ploughs. The invention consists in laying down a chain or rope the whole length of the field to be ploughed which is fastened at each end, and is made to pass round a grooved wheel or pulley on the machine; as the grooved wheel or pulley is caused to rotate by the engine the machine is drawn forward. A further modification of this plan consisted in the use of a short endless chain in place of the long chain. The endless chain was passed partly round the pulley or grooved wheel on a detached carriage, which was kept at a proper distance from the machine by means of spars in such a way as to precede the machine and keep the chain properly distended. The system of the rope hauling described in the first part of this invention, was introduced by Messrs. Beadon and Smith, and Sir J. S. Lillie, in 1847, by C. Arnoux in 1853, and by Messrs. Fisken in 1855.

In 1814 Thomas Tindall patented an invention for working agricultural implements by means of connecting such implements to a traction engine, and drawing them over the ground to be operated upon. The engine invented by Tindall was intended to be propelled by "four pushers or legs at the back of the carriage, to come successively in contact with the ground, and impel the carriage." "Ploughs, harrows, drills, wheels with scythes affixed thereto, or other implements," may be attached to the carriage, and used as required in carrying out the various processes of husbandry.

Inventions identical in principle with this were again introduced by David Gordon in 1824, by John Leo Nicholas in 1840, by Messrs. Teisser and Triat in 1845, by J. H. Pape in 1851, and by D. D. Kyle in 1852. All such inventions as these are only interesting as matters of history, and as showing the very great amount of thought that has, from time to time, been lavished on inventions that have soon been superseded by others better adapted for the purpose for which they were introduced.

In 1816 J. Reynolds proposed a traction engine in which the boiler was suspended, so that whatever the position of the machine, the boiler was always horizontal. The engine was to be applied for the purpose of drawing "rollers, ploughs, cultivators, twin barrows, drilling machines," &c. The arrangement of the boiler may be considered a great advantage in a machine that would have to traverse very uneven ground.

In 1832 Mr. John Heathcoat proposed a series of modes in which steam power could be applied to the cultivation of the soil, one of which related to the construction of an arrangement of traction engine, consisting of "a carriage of large dimensions, fitted with a steam engine, or other motive power machine, and suitable winding gear, and mounted on a series of wheels, which conduct an endless flexible floor, railroad, or way, within and upon which the carriage is caused to travel by the power of the engine." Other modifications of this engine were propounded by the inventor in order to adapt it to give motion to rollers; also to fit it as a machine for giving motion to ropes that should be applied in drawing implements, which portion of the invention will be hereafter described under its proper head.

In 1837 Mr. John Upton invented a traction engine for drawing ploughs and other implements over land, the distinguishing feature of which consisted in the application of a rotary steam engine for its propulsion.

In 1839 Mr. Henry Pinkus proposed a series of inventions for cultivating the soil, of a highly philosophical character; the main feature of which consisted in providing a central station containing the power, or prime mover, from which a series of underground pipes radiated to convenient parts of the farm. The power of the prime mover at the central station was to be transmitted through these pipes either by compressed air, or by exhausting the pipe and so creating a vacuum; or the pipes might be used for the conveyance of gas from the central station; and, in 1840, the author also adapted the foregoing arrangement so that the power of galvanic batteries at the central station might be transmitted and communicated to a travelling "electro-magnetic engine." From the pipes or insulated wires, as proposed to be laid down by the author of these inventions, at certain distances junctions were to be made, so that the travelling engines could be connected with the wires or mains. The engine used for the purpose of drawing any agricultural implement, carrying a revolving reel, on which either a flexible tube or insulated wire were intended to be carried; the inner end of the tube or wire was attached to the working parts of the engine, and the outer end was connected with the underground pipes or wires, and so the machinery was put in motion; and, as the engine advanced, the flexible tube or wire was uncoiled, if receding from the junction with the underground pipes, or was wound up, if approaching the junction. The invention also relates to the substitution of a large vessel or reservoir to take the place of the reel and flexible hose, which reservoir will act as a reserve of power either by being exhausted of air or filled with gas. In this invention, when gas was intended to act as the motive power, the power was produced by the "explosion of mixtures of carburetted hydrogen or similar gas and atmospheric air in close chambers, so as to act against pistons and put them in motion." Should the gas engine ever make such progress that its power may be depended on with the same certainty as steam power, and the power produced at as cheap a cost as that of the steam engine, then we have in this machine an embryo invention that may ultimately, in some situations, drive the steam engine out of the field, especially in those districts where it is difficult to procure water except at very great cost.

In 1846, Sir James Caleb Anderson proposed a mode of working a traction engine to be used for the purpose of cultivating the soil. The engine was provided with a drum, round which a rope was intended to be passed in such a way that, as the rope was being unwound from one part of the drum, it was being wound up on the other part, and to each end of this rope an anchor was attached. When in operation, it is intended that one of the anchors should be carried forward and fixed in the ground a considerable distance in advance of the engine which, being then put in motion, draws itself and implements up to the anchor. While this is being done, and as the other portion of the rope is being unwound from the drum of the machine, its anchor is intended to be carried forward by horses, so that, when the engine has travelled up to the first anchor and its motion is reversed, it will travel to the second anchor; and by a succession of similar operations the whole field or farm is intended to be cultivated. The same mode of traction was proposed by John Fowler in 1850, by D. S. Brown in 1852, and by R. Roger in 1856.

In 1846, Messrs Bonser and Pettitt introduced a rotary cultivator. This machine, in one form, is intended to be drawn by horses; but it is mentioned that its inventors intended that it should be drawn by "any other suitable agent." The invention consists "in employing for the purpose a tiller, formed of a cylindrical shaft or drum, having a number of radial cutters, or prongs or tines, either straight or curved, attached thereto at right angles, and arranged round it spiral-wise, so as to present the appearance of a screw."

In 1846, Mr. James Boydell took out his first patent for a traction engine to be used for the cultivation of the soil by the agency of steam power, which was further improved and again patented by him in 1854. The principle of this machine has been already described in the description of the invention of Edgeworth, in 1770; and the main features of the invention consist in the increased area of bearing surface that is given to the wheels by placing under them a broad portable tramway, which is moved and relaid by the engine as it progresses.

In 1847, Sir John Scott Lillie introduced certain machinery for tilling the land, which consisted in the application of ploughs and harrows attached to a carriage impelled by steam power. The machine has two sets of wheels placed at right angles to each other. One set support the carriage and implements when ploughing or cultivating the soil; the other set are lowered and brought into action when the machine is required to move sideways, in order to bring the machine to operate on fresh land. On each side of the carriage are two skeleton drums, which carry an endless tramway formed of planks and wrought-iron plates hinged together, on which the bearing wheels of the machine travel. A double mould or ridge plough is fixed at each end of the carriage, in order to clear the way for the bearing wheels of the machine. The cultivating apparatus consists of a rotary cultivator, driven by gearing from the main wheels of the machine, which rotary cultivator is preceeded by coulters, or cutting irons, which are attached to the frame of the machine. The invention also relates to the application of "a high pressure steam engine on the carriage frame for the purpose of impelling the machine, by turning a whelp wheel, and causing it to draw in a rope" attached to grapnels on each side of the field, in a manner somewhat new.

At different times various machines have been proposed that imitate more or less the ordinary operations of manual labour in the cultivation of the soil. One of these machines was proposed in 1847, by Pierre P. C. Barrat, and consisted in an "arrangement of one or two rows of teeth, to which, on the one hand, a rotary alternate movement is given, and, on the other hand, a to-and-fro movement, in such a manner as to imitate as much as possible the work of the hand with a mattock, whereby the earth is returned to the ground after it is raised." This machine consists of a steam carriage mounted on four broad wheels, and supplied at the back with a frame, containing two rows of mattocks. Each mattock has a fished head, and is fitted to a straight shaft or handle. Each handle is inserted in a metal socket fixed on a horizontal shaft, upon which it is capable of freely turning, in order that all the mattocks may have an independent action. All the mattocks are mounted on the same shaft, yet they act in two rows; this is owing to the handles of the row nearest the shaft being shorter than the handles of the mattocks in the other row. "The mattocks of the foremost row enter the earth to the depth of from 7 to 12in., according to the nature of the soil; while those of the back row work in the place where the front mattocks had previously operated, and penetrate the earth to a greater depth." The shaft that carries the mattocks has two distinct movements, or a rectilinear movement in guides attached to the frame of the machine, and "an alternate circular motion." The penetration of the mattocks into the soil is increased by the pressure of a spring acting on them.

The system of rotary cultivation has had many advocates, and at one time was in great favour; great things were expected of it. We have already seen that Bonser introduced rotary cultivators in 1846, and Sir J. S. Lillie in 1847; in 1849 James Usher introduced a rotary cultivator and traction engine. In this invention the author fixes a number of curved ploughs in the same plane round the axis of the shaft that carries them, so that they come into action alternately. The power of the machine is applied to give motion to the revolving ploughs, and these ploughs, as they enter the earth and travel through it, cause the machine to travel forward.

As further examples of rotary cultivators, we may take the invention of John Bethell, which was patented in 1852, which apparatus consists of a rotary digger attached to an ordinary steam engine, It consists of a number of prongs or tines arranged round a drum or shaft in a helical direction. The rotary cultivator turns in bearings, made at the end of a frame, or a pair of lever arms, secured to either the front or back part of the carriage in such a manner that it may be raised or lowered as may be required. The steam engine in this case actuated the revolving cultivators by means of a band driven from a rigger on the main shaft of the engine; and, when put to work, it was intended that the whole machine should be drawn over the land to be cultivated by horses. From a statement made by Mr. Bethell at the Society of Arts in January, 1856, it appears that up to that period the machine had been at work with various alterations, which from time to time suggested themselves, for three years; and it is stated, "it dug like Parkes's steel fork, and left the ground in perfect state in tilth after the separation; it threw the earth up into the air, the earth falling first, because the heaviest, and the weeds coming upon the surface. They had no difficulty in working about four or five acres per day with that machine. It dug down to the depth of 9in.. and farmers who had seen it working had stated that it did as much in one operation as would require two or three ploughings to perform, besides scarifying, harrowing, &c. The estimated cost of it was about 9s. per acre, whereas 23s. was stated to be the cost under the ordinary mode. The experimental engine was worked at a pressure of 45lb. In 1857 Mr. Bethell further improved upon his machine by attaching it to a locomotive engine, the wheels of which were fitted with Boydell's rails.

In 1853 Mr. R. Romaine, of Peterborough, Canada, obtained letters patent for "digging, pulverising, levelling, drilling, and rolling the soil, sowing seeds, depositing manures, reaping and mowing, making drains, and performing other agricultural operations by mechanism actuated directly by a steam engine, but traversed or conveyed over the land by horse power, or by the power of an additional steam engine. In January, 1854, the author of this invention proposed to substitute a rotary engine for the reciprocating engine to propel the machine. The invention was further improved by him in July, 1854, and January, 1855, and again in September, 1856; and, by virtue of the various improvements, it was made a traction engine working the rotary cultivator attached to the frame.

The first machine drawn by horses was tried on Mr. Mechi's farm, and failed at its work. The high velocity of the cultivator required more power than was capable of being supplied. One of the most successful of Mr. Romaine's machines was manufactured at the Beverley Ironworks, under the direction of Mr. Alfred Crosskill. The latest form of engine consisted of a double cylinder 12-horse power engine and boiler attached to a suitable frame, which was mounted upon a pair of high wheels, with two wheels at the front for steering, and a fifth wheel at the back for regulating the depth of the cultivator. The cultivator consisted of a drum, 2ft. 6in. in diameter, made of boiler plates, on which were fastened the ploughs or tines for cultivating, somewhat resembling the scarifying paring shares of Coleman. The cultivator was so arranged that it could be lowered by a toothed rack and screw motion to any required depth, and was actuated by parallel connecting rods transmitting the power of the engine from the toothed gearing at the fore part of the machine. The cultivator, when at work, made from 40 to 50 revolutions per minute, and the machine was propelled forward at the rate of about "a mile an hour." The rotary cultivator of this engine was much wider than the track of the engine, so that, when at work, it entirely obliterated the track made by the wheels. This machine cost £800, and is stated to be capable of cultivating from four to seven acres of land per day, at a cost varying from 5s. to 10s. per acre.

A machine on this plan, but somewhat simplified, is described by Mr. Algernon Clarke in his prize essay on the "Application of Steam Power to the Cultivation of the Soil;" it was manufactured by "Mr. W. H. Nash, of Cubitt Town, Isle of Dogs." The whole machine was 18ft. long, 10ft. wide, and weighed 12 tons. The cultivator was 8ft. wide, the whole diameter from the extremity of tine to tine was 53in., and the tines projected 10in. from the drum of the cultivator. The weight of the cultivator is "about 7 cwt., and in its lever frame it is free to play up or down, in order to meet the irregular contour of the ground to be cultivated, but is guarded against any severe variation in depth by the wheel that regulates the depth of the cultivator. Owing to this arrangement of the cultivator, while it will cut up any ordinary obstruction to its progress, it will rise out of its work and pass over any impediment that it cannot break up. In this machine the implement is lifted out of its work by two cylinders and pistons, to the rods of which chains are attached, which are secured to the lever frame of the cultivator, so that when steam is admitted into these cylinders the lever frame is raised to any required height. Mr. Clarke says that he saw this machine at work at Royston, in Cambridgeshire, "on a piece of mown stubble—a light, chalky, turnip soil, of a quality that turns sticky with wet, but dry and friable at that time. The main wheels, of $6\frac{1}{2}$ft. in diameter, made of T-iron spokes, and plate-iron felloes. 21in. broad, sunk very considerably into this land, plainly showing the necessity for having flat platforms, like those of the 'endless railway,' over which the heavily weighted wheels might roll, but the difficulty of turning short round upon these 'shoes' appears to be hardly overcome at present. The shares or cutters were arranged three in a row or ring, three successive cuts being made in one revolution of the cylinder, and the advance for each cut being about 6in. The digger made 30 and 40 revolutions per minute, the engine running at from 120 to 160 strokes per minute, varying according to slight elevations and depressions in the ground. The earth was well subdivided by the thirty-three cutters (that is, eleven in a row), and turned up in small spits, beautifully broken, much like spade work, the depth not exceeding 6in., or rather 6in. at one end of the digger and 4in. at the other, owing to want of rigidity in the lever frame. This it is proposed to remedy by partly bearing up the end which is not supported by the small travelling wheel by means of the 'hydraulic,' and this wheel also is to be placed exactly opposite the end of the digging cylinder, so as to adjust the depth of the culture more accurately. In deeper tillage the action of the machine is far more effective and economical, and it is able to dig 12in. and even 16in. deep. A length of 23 chains was 'cultivated' in 23 minutes, including $1\frac{1}{2}$ minutes stopping, turning, and setting in again; and, as the breadth of the work is $7\frac{1}{2}$ft., the extent dug in a day of 10 hours is nearly 7 acres. The engine, working at 70lb. pressure, may be called 20-horse power, though it may be worked up to 80 or 90lb. if required, and hence the expenses may be estimated." which he estimates at from 6s. to 6s. 6d. per acre, the machine costing £700. At the same time he states that "this is extraordinary economy, when we consider the effective character of the tillage, and that work 10 or 12in. deep would cost but little more, that is, merely extra fuel for the greater power engaged."

In the same year that Mr. Romaine procured his first patent, Mr. C. W. Hoskyns patented an idea of a rotary cultivator, or, as it has been called, a rasping or scratching machine. This invention is the same in principal as that of Mr. Romaine, and, in the inventor's language, "consists of a machine for the cultivation of the soil, more especially clay soils, by steam power, applied in such a manner as to accomplish at one process the due preparation of the soil for a seed bed. This result is obtained by a machine which, instead of lifting in mass the stratum of earth under cultivation, like the plough or spade, is so applied to the soil as to reduce it by abrasion to the required tilth or fineness. This abrasion is performed by a series of discs or wheels, fixed on a rotating axis actuated by steam power, the pheriphery of which discs are furnished with radiating points or cutters. The rotary motion of the discs is communicated from the steam engine, from which also the progressive motion of the machine is derived. The two motions are independent of each other, and so arranged that a rapid motion may be given to the cutters, while the progressive motion is slow, or suspended altogether, as at commencing. The gearing is such that the respective speeds can be varied at pleasure to suit the nature of the soil. The cutters, by their rotary action, first enter the soil, making a semicircular trench, which, during the progress of the machine, is constantly preserved at the required depth, and the soil, abraded and cut down as the machine advances, is thrown off tangentially behind, and deposited in a comminuted, inverted, and aerated condition."

In 1857 Mr. T. Rickett procured a patent for a machine differing in one essential feature from the rotary cultivators already mentioned; viz., that, while all the rotary cultivators before described have revolved in the direction of the advancing machine, and therefore rather favoured its propulsion, in this machine of Rickett's the cultivator in revolving was opposed to the motion of the engine in advancing, and the earth was raised by the cultivator, carried completely over, and deposited again by its own gravity at the back of the cultivator. The supposed advantage of this mode of working the cultivator is, "that the cutters are better able to cope with stony or very hard soils, and, entering the unmoved ground at the full depth, they avoid the difficulty of penetrating from the top when dry and baked by the sun;" but these supposed advantages would only be met with when working a moderate depth; for, as a rule, the hardest ground is found in the "pan, or indurated stratum of subsoil" that has already been referred to, and by the aid of steam power its destructive effects should be removed.

Of necessity, this rotary mode of cultivation being in great repute, we find that a number of persons have turned their attention to perfecting it; and, in addition to those already mentioned, we have the invention of D. S. Brown in 1851, of T. Lawes and D. S. Murphy in 1852, T. Atkins and P. Kelly in 1853, B. Coles in 1854, and R. Roger and Messrs. Moncton and Clark in 1856. The great object of these rotary cultivators has been by mechanical agency to produce a perfectly comminuted seed bed at one operation; and, so far as finely dividing the soil, they have been tolerably successful; but it is found by experience that a seed bed prepared in this way is not exactly what is required; for, as Mr. Clark says, "the indispensable value of a comminuted seed bed, and the utility of a seed bed comminuted mechanically, are two different things. In the latter case the particles are all dry and ready to seize and coalesce with each other with the cementing moisture of the first rainfall; but when wrought down from a state of clods by the natural process of weathering, they are independent and repelling, rather than inclined to suck and adhere to one another, their pores being replete with the moisture which has burst them into atoms out of solid cakes and slags; and thus we have both a cheaply obtained comminution and a more permanent mould for the elements to permeate, and for roots to roam and feed in."

A great variety of traction engines have been invented at various times with a view either to drag ploughs or other implements over the soil, and so to cultivate it, or for the purpose of drawing wheeled carriages on common roads. One of the most modern engines is that of Messrs. Aveling and Porter. It has already been shown that various modes have been proposed at different times in order to adapt the power of the steam engine to the progressive motion of the machine. In most modern inventions the power is communicated direct to the wheels of the machine, but in 1856 a mode of propulsion was proposed by J. A. Longridge, which is here mentioned as showing another variety of the means that have been proposed for propelling traction engines. The mode of propulsion consists in the "application of a screw, somewhat similar to the well-known screw propeller, to the propulsion of a locomotive carriage over land for agricultural purposes, the motive power being placed on the carriage, which moves on wheels (or rollers), while some portion of the weight rests on the screw propeller, which is partially immersed in the land. The motive power is applied to the rotation of the screw, which advances and propels the carriage over the ground. The implements of culture may either be affixed to the same carriage, or attached to another frame or carriage impelled by the locomotive screw carriage." The application of power in this way is stated by its author as "principally adapted for the traction of ploughs, or other implements for inverting the soil, in which a great amount of traction force is required."

The idea of applying traction engines to drag implements of culture over the ground probably was taken from the mode adopted in horse labour, the steam horse being substituted for the ordinary power, but it was be seen, from what has already been stated, if horse labour has proved destructive to the interests of agriculture, by reason of the trampling and puddling of the ground, that the substitution of a heavy machine moving slowly over the ground will cause great damage by the undue consolidation of the soil. Moreover, the application of the power is found to be less economical when a heavy machine has to be driven over the soil; for example, we have seen in the case of Mr. Romaine's rotating cultivator that the cultivating implement only weighs 7 cwt., and, for the purpose of working it, an engine weighing 12 tons had to be propelled over the land. The great power required to propel a heavy machine over rough ground will more than counteract any advantage that may be supposed to be derived from the direct application of the power to the implements of culture; and, as the period of the year in which a traction engine could be allowed to enter upon the land with safety is very limited, the result has been that traction engines have not realized all the advantages that steam culture is capable of imparting, and therefore we find that they have been superseded by other inventions more economical and combining greater advantages.

(*To be continued.*)

## INAUGURAL ADDRESS OF THE PRESIDENT MR. F. W. BRYANT, C.E.

In taking my place for the first time as President of the Society, I thank you for the honour you have conferred on me in selecting me your president, an honour which I greatly esteem, and hope, with the assistance of the council, and the co-operation of the members generally, that I shall be enabled to carry out my duty to the satisfaction of all, and the advancement of the Society. It is now more than ten years since I joined this Society, and I have much to thank it for in enabling me to glean a great amount of information in the various branches of the engineering profession which I could not have obtained by my own practice alone. Therefore I consider a society like this is of great value to a young engineer, and in many cases to those who are seniors in the profession. If a member attends regularly at our meetings, as he ought if he possibly can, I do not believe there is any paper read, or lecture given, from which he may not obtain some advantage, either from the paper itself, or by its causing him to think on the subject on which the paper is written. Then there are our visits of inspection to the important works in and around London, which, I trust, may be extended to more distant localities, as occasion affords. These visits, excellent in purpose and effect, are most valuable to all the members who attend on those occasions; for it is not only from one's own observations, but from the remarks of, and discussions with, those present at the time on the works actually in progress, that he who seeks to learn has every opportunity of so doing. One of our older institutions, which holds a periodical meeting of the larger manufacturing towns, is an instance of the advantage of these visits, as there is no doubt that the large increase of its members is mainly owing to this arrangement. I have much pleasure in remarking the kindness and courtesy with which this Society has always been received at the various works it has visited from time to time. I am happy to say I can congratulate you on the general advancement of the Society, both in numbers and position. When I first joined the Society we numbered but 117, and now the number of its members and associates is quadrupled.

We have as honorary members many of those who take rank amongst the highest scientific men in the world; and as regards the members and associates of our Society, we have representatives of every branch of the engineering profession. There is scarcely any part of the world where engineering works are being carried out that some of them are not to be found, working either as principals or assistants.

True it is that since the last financial panic there has been considerable depression in our profession, owing to the want of confidence engendered by over speculation; but that can certainly not be the fault of engineers. Doubtless it is the duty of an engineer to carry out works as economically as possible; but there is another duty which he should be most careful of and that is, not to under-estimate the value of any work, as that will inevitably lead to confusion.

Difficulties occur both at home and abroad which one could scarcely expect to have been foreseen; for after all an engineer is but a human being, though sometimes it seems as if he were expected to see beyond "mortal ken." I hope and believe that this depression will be gradually removed, and that we shall see engineering improvement increasing here and abroad, to the advancement of our profession and the benefit of mankind. I say to the benefit of mankind; for is it not to the drainage engineer that we owe the health of towns and agricultural improvements; to the railway engineer, quick transit, the removal of goods, and the opening up civilisation of whole districts; to the dock and harbour engineer, the safety of the navies of the world, and so on to all the branches of our profession, which tend directly or indirectly to the good of mankind in general?

And although there has been this depression, and men say "there is nothing more to be done in England," surely this must be wrong. Are all our towns properly drained, all our rivers bridged over, all the docks, harbours, piers, and lighthouses, defence of shores (much wanted in many places), all water supplies and irrigations completed, all connecting lines of railways made? Are even the existing main lines perfect? Recent accidents lead us to think that it will be necessary to have separate lines for passenger and goods traffic; in fact, some of the engineers are taking steps to secure the necessary ground; is the utilisation of sewage properly done? Surely, then, with the return of public confidence in properly matured schemes, we may hope that engineers of Great Britain may find that there is yet something to be done in their native country. In and around London of late years there have been many great and remarkable works executed, some not yet completed, and I can scarcely imagine a better school for engineers, if they have properly studied the different important engineering operations that have been carried ont. Many of these works will mark the present era of engineering for centuries to come. Take, for instance, that grand work the Thames Embankment, although not yet completed, the portion now opened shows the great improvement it will be to London. I hope to see it extended on both sides of the river, so that the improvement may be made complete in the metropolitan district. The main drainage works are in full progress, and in a comparatively short time we shall doubtless have London perfectly drained, and, as a natural result of this, the health of the inhabitants improved. The river Thames has decidedly improved in purity during the last few years, as I have had good opportunity of knowing. Various kinds of fish, from the dace to the porpoise, certainly made their appearance during last summer in the neigbbourhood of Blackfriars-bridge. Then we have the Metropolitan outer and inner circle railway; although not quite completed, yet the work already done is sufficient to command the admiration of all observers, professional or non-professional. I consider it, as a work, a credit to our profession.

Such a varied practice cannot have occurred in any other railway I know of, and it is, I think, a good example, showing that whatever difficulties arise in the construction of works, they can be successfully met by a good engineer. Then there is the East London Railway in course of construction, which will, no doubt, be of great service when completed for public traffic; also other small branches, which are of importance to the main lines they belong to, and all tending to complete the railway system. We have also had new docks—I allude to the Millwall Docks—opened during the last year, and improvements and enlargements at the West India Docks, which will, no doubt, be appreciated by the mercantile communities of London, and I may say of the world. Good dock accommodation is a great desideratum, though sadly neglected in places where it is greatly needed. There are many positions on the coasts of England where good docks would be of great value and convenience, and I hope to live to see many such positions, naturally formed for harbours and docks, taken advantage of for their construction. The bridge over the Thames at Blackfriars has made good progress during the last year, and I expect to see it open for public traffic about the middle of this year. This will also be a great metropolitan improvement. The Holborn Valley Viaduct will be of great utility, and is also progressing rapidly towards completion. There is an improvement very much wanted in London, and that is a footway bridge crossing over our principal thoroughfares; and in places like Regent

Circus or the bottom of Fleet-street, a four-way bridge would be very desirable. I see no reason why they should not be tried. A light iron structure might be erected at a trifling cost, and would very soon prove if it were of practical use. Engineering work in Great Britain has generally been very slack during the last year. It has had many things to diminish its chance of prosperity. The Abyssinian war, the unsettled state of and revolution in Spain, and the doubtful position of politics with regard to war in Europe, all tended to the stagnation of work. For the prosperity of civil engineering peace is absolutely necessary, and I hope and think we may look forward to it with confidence.

The general election, without doubt, materially interfered with engineering establishments all over the kingdom. I think, however, I may congratulate you on the fact that the prospect of increase of work is decidedly brightening in the iron districts, which is a good criterion for our profession generally, although report states that Belgian houses have an immense amount of work in hand. The *Iron Trade Review* of December 23rd, 1868 states that they "have now secured, or are in treaty for, contracts to the extent of something like 90,000 tons of rails;" and further on remarks: "We may ask what English firms durst venture to take contracts for such a period in advance in the present state of the market, in consequence of the constant insecurity from a movement on the part of workmen for advanced wages? and experience has shown that this is almost sure to be their tactics whenever they know that employers have heavy contracts on hand." This, I am sorry to say, I believe to be the case. Every man has a right to obtain as much as he can for his labour; but it is unfair, after a master has taken a contract, for workmen to demand a rise of wages before the completion of that contract, and it is much to be regretted that workmen should do so, as in many cases it prevents the ironmasters of England from taking work. It is a difficult question, but one of great importance, to institute a proper system of arbitration between men and masters; and whoever could arrange a good method of effecting this would be rendering his country a great service. The export trade of manufactured iron into France has decreased by some 5,000 tons in 1868 from that in the preceding year, still I perceive a great probability that the decrease will be altered to an increase during this year. I am glad to find, also, from public reports that our exports of iron to America are decidedly on the increase; and from the friendly relations now existing between the two countries, and also from the low state of stocks of iron generally, we have every reason to expect that our exports will be much larger during the present year, and I most sincerely trust that not only mutual improvement of commerce, but of good feeling, will continue between Great Britain and America and all other parts of the world.

Certain I am, with regard to our nearest neighbours, that the sentiment of peace which the Emperor has lately expressed confirms my idea of the probable increase of trade generally. While on the subject of iron, I have great pleasure in remarking that we have to welcome a new society lately formed, under the title of the Iron and Steel Institute, and I learn in the short space of two months 150 gentlemen directly connected with the iron and steel interest have signified their intention of joining the new institute. There can be no doubt that much good will result from the information they will be able to afford our profession. In Great Britain there have not been very many engineering words of great interest carried out during the last year. The principal amongst those completed is the bridge over the Mersey at Runcorn and the viaduct over the Solway. Of those in progress there is also a bridge over the Trent at Nottingham, which I believe will be a very excellent example of its sort when finished. I may also mention the Chatham Docks. These works are on an extensive scale, and will no doubt be of great value to the service they are required for. Then there is the new dock at Hull, the Sunderland Docks, and the Tyne improvements. One of the most important questions that engineers have before them is that of town drainage and irrigation—a subject that has been particularly brought before us by our late president, who certainly has given us the benefit of his considerable practice in that branch of civil engineering, and for which we have much to thank him. The boldest of the proposed engineering works connected with England is that of passing under or over the Channel, for which we have three schemes, *i.e.*, by means of a bridge, a tunnel, or a steam ferry. The first of these I do not expect to see carried out; the second I believe to be quite practicable, the cost appearing the great objection; the third seems to me the most practical proposition, and I have no doubt would be found of great service to the public. On the Continent during last year there have some remarkable works completed and many in progress, and if peace continues and Spain settles down to working instead of fighting I think we may reasonably expect a considerable advance in engineering works. In that country there is a considerable field for engineering of all kinds; in Turkey also improvements are much wanted, railways more particularly. Then there are the Wallachian lines to be completed, and I understand some large contracts have lately been taken in that part of the world by English contractors. This year in Russia there will be heavy railway works in progress; Italy and Sicily will possibly add something to the European railway system. The most remarkable railway work opened for traffic during the past year is that over Mont Cenis, and, in spite of differences of opinion as to details in working, it must be considered a great engineering achievement. Its rival, the Mont Cenis tunnel, is gradually progressing towards completion, and when it is done will solve the problem of under *versus* over mountain travelling. Bridge engineering has also been represented by some very fine, and, in some cases, novel structures. Perhaps the most novel, and certainly one of the finest, is that over the Moldau at Prague, on the rigid suspension principle, which seems to be very successful, and I am very pleased to remark that Mr. Ordish, the engineer of this bridge—an old member of this Society and one of its presidents—has been presented by the Emperor of Austria with the gold medal of Arts and Sciences of that country on the opening of the bridge, and Mr. Wessely, one of our prizemen, the gold order of merit for the part he has taken in the construction of the bridge.

One of the finest railway bridges in Europe has been constructed over the Rhine at Kuilemburg, in Holland, which does great credit to its engineer and those who have carried it out. Its construction is, doubtless, familiar to you all, through the medium of the London scientific papers. It is remarkable for its large span of 492ft. in the clear.

Among numerous great European works in progress may be mentioned the docks at Havre, which will, I understand, be very fine when completed; and drainage works and canals in Holland.

Let us now travel eastward, and, crossing into Africa, we come to one of the grandest works of modern times—the great ship canal across the Isthmus of Suez. Already a small schooner, La Levrette, has made a passage by the canal across the isthmus; and I learn, on the best authority, that in about six months it is probable vessels of the largest size will be able to pass through the isthmus from sea to sea.

If this is realised, what a great engineering triumph it will be—perhaps even altering the fortunes of nations. Certainly it will make a difference in our Indian trade, but time will soon make a great show; and it is scarcely worth theorising when we shall so shortly know what the result will be.

(*To be continued.*)

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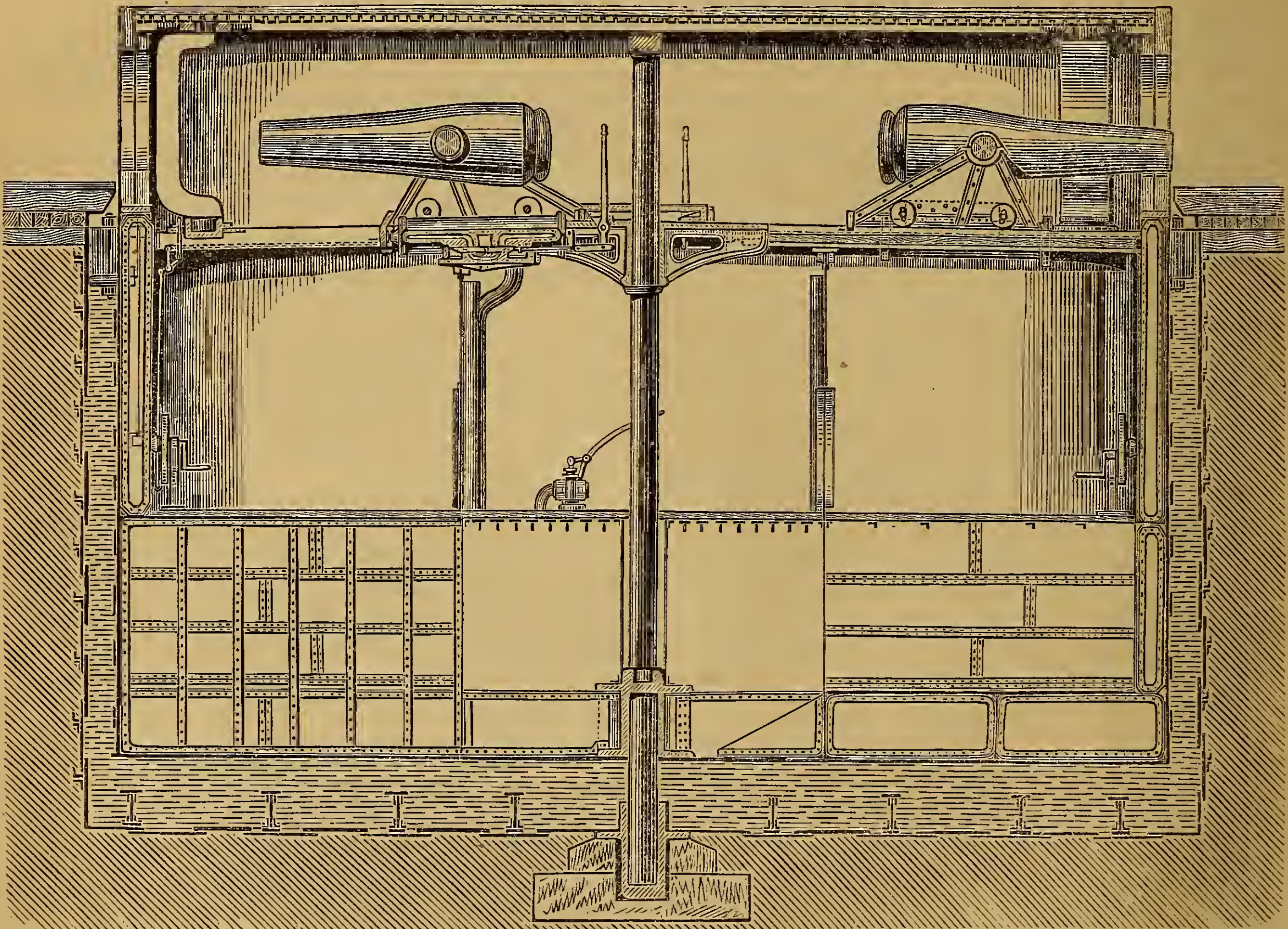
## REVOLVING IRON-CLAD FORTS.

By MESSRS. RYAN AND HITCHCOCK

The partial failure in the attempt to construct iron-clad forts for the protection of our dockyards, combined with the enormous outlay already incurred, will, we think, be sufficient excuse for extracting the following account from the *Scientific American*, of a very simple and ingenious American invention :—

"Of late the science and skill in the manufacture of large guns is so far in advance of the power of resistance in ships when they are clad up to their maximum load, that they are not at all reliable; and the old fortifications are still more unreliable; hence the necessity of corresponding improvements in forts and other means of defence. When our largest guns consisted of 68-pounders, it was but pastime for the brick mason and stone cutter to construct fortifications. But now 600 or 1,000-pounders have reduced all such fancy structures to worthlessness. It is now guns *versus* forts, iron and steel against iron and steel. But the iron-clad is now more than a match for the old fort, and iron plating has heretofore proved a failure, therefore we see great energy and anxiety exhibited by foreign nations to protect their fortifications. To preserve their guns in barbette they mount revolving turrets on the top, and in the angle of their forts, but this as a naval defence will prove a useless experiment. Other experiments are proposed, such as adopting "rifle pits" on a large scale, with guns so mounted that they "get themselves up and fire over the top of the pit and then get themselves down again to be reloaded;" and, lastly, it is proposed to mount a miniature fort on trucks to be propelled by a locomotive engine; this locomotive fort to travel on an annular inclined railway, coming round from behind a shield or casement moving up the incline and firing over the embankment, and then gracefully retiring. These somewhat novel devices tend to show the drift of the practical mind, the utter incapacity of the present mode of constructing fortifications, and the consciousness that something must be done, and that soon, to solve these two great problems; yet no two engineers can agree, but leave them, as they found them, unsolved. We know, too, that the very existence of some Governments depends on the solution of one or the other of these problems. We know that Governments that have the most forts, really have the least confidence in them, and are surrounding them with ironclads, floating batteries, and torpedoes. One writer says that the British Admiralty have made a "lamentable failure of the Plymouth forts and Gibraltar shields," and it is well known that in some cases they plate the tops of the fort, leaving the base exposed, when they know by actual experiment that a single shot has "splintered" granite blocks 15ft. back from the face, or point of impact. Naval tactics are being reversed; forts were formerly used to protect ships, but now ships have to protect forts, such as they are. Doubtless the true theory is mutuality; one auxiliary to the other.

In view of these facts it is claimed that the Revolving Hydrostatic and Pneumatic Fort satisfactorily solves the first problem; how best to defend ourselves against an enemy's ships. Accompanying this article will be found a plan, reduced from working drawings drawn to a scale, to admit of eight 15-inch guns, and is 58ft. diameter on the gun deck. It gets its flotation by being inclosed in an iron tank, say 2ft. greater in diameter than the bottom section of the fort, having the intermediate space filled with water. The upper section, or fort proper, is constructed entirely of iron or steel plates of any given thickness; in this plan it is proposed to use three thicknesses of six-inch plates, which are now considered sufficient to resist any projectile that has been contemplated. It is only a question of buoyancy, whether this fort be one foot or four feet in thickness, which is governed by the superficial area of the base or lower section immersed, so that, it will be seen, this system is unlimited in its capacity. The lower section is divided off into store rooms for provisions and ammunition, and into quarters for officers and men.



A fort of this kind weighing 1,500 or 2,000 tons may be revolved easily with three or four men by simply turning a crank, thus enabling us to handle eight 15-inch, 20-inch, or 30-inch guns.

Suppose science and mechanical skill should produce wrought iron or steel guns of 50 tons or more, with a 24 or 30-inch calibre, which may be considered at least possible, they could not be used on board of ships, nor do we think they would be practical in the present fortifications; but on this hydrostatic principle such guns can be trained as expeditiously as guns weighing only ten tons; and by an ingenious arrangement of compressed air, which takes up the recoil of the monster pieces and runs them again into battery by the power of a single arm—together with other appliances to facilitate loading, opening and closing the port stoppers—Captain Ryan's system insures a great saving of men and time. And it will be borne in mind that this revolving fort effectually counteracts the advantage heretofore held by ships under steam and constantly in motion while in the act of bombarding; for this fort can also be kept in constant motion, so that the lateral range when got, need never be lost on a moving ship—overcoming the most difficult part of gunnery in fortifications. This fort can also be located in positions where it would be almost impossible to erect an ordinary fort; as, for instance, in low marshy land or on quicksand, this fort may be set up in a short time by simply excavating a pit large enough to receive the iron tank, when the foundation is ready for an eight gun fort, equivalent to a 50 gun fort of the present construction; and if it be exposed to attack from land, it still maintains its permanence as a defensive work, as nothing short of insanity could induce infantry to assault such a fortress; for so long as provisions and ammunition hold out a garrison of 50 men in its iron shield could never be made to surrender. The attack of a siege train would be quite as futile; starvation or treachery might capture one of these forts, but powder and ball never.

All the advantages pertaining to the revolving fort may be transferred to a floating battery by constructing a solid timber platform or shield 150ft. square, more or less, from 12ft. to 20ft. deep, with proper fastenings, and plated with iron, to be ram and shell proof, leaving in the centre a well-hole through the shield of requisite diameter to receive the fort, in which case it will be seen that the timber shield is a substitute for the iron tank, with this difference that it has no bottom but the sea. In case of necessity this immense shield is towed into position and securely moored. To an obstruction of this kind rams and iron-clads will give a wide berth.

## SHIP-BUILDING ON THE CLYDE.

While the trade of ship-building has been languishing so distressingly upon the Thames, in consequence of the excessive rate of wages demanded by the shipwrights, platers, &c., the Clyde ship-builders have been steadily increasing their business, until they are now almost, if not quite, as full of orders as they were during the American war. Although during that period they turned out (in 1864) about five per cent. more tonnage than last year, it can scarcely be considered as satisfactory as the present steady, legitimate trade, without any such exciting cause. The following is a general summary of the state of the trade during the past six years, together with the prospectus, so far as can be ascertained, of the present year:—

| | 1867. | | 1868. | |
|---|---|---|---|---|
| | No. | Tons. | No. | Tons. |
| War Steamers | — | — | 8 | 5,384 |
| Paddle Steamers (Iron) | 26 | 9,150 | 18 | 6,291 |
| Screw Steamers (Iron) | 77 | 52,206 | 78 | 78,359 |
| Do. (Composite) | 1 | 267 | 4 | 2,882 |
| Screw Hopper Barges (Iron) | 4 | 1,200 | 8 | 1,900 |
| Steam Dredgers (Iron) | 2 | 900 | 2 | 485 |
| Sailing Vessels (Iron) | 44 | 34,116 | 73 | 63,799 |
| Do. (Composite) | 9 | 7,969 | 16 | 13,313 |
| Do. (Wood) | 13 | 3,045 | 14 | 2,234 |
| Yachts (Wood and Composite) | 9 | 625 | 6 | 331 |
| Total Vessels and Tonnage Launched | 241 | 114,598 | 227 | 174,978 |

### Comparison of the last Six Years.

| | 1863. | | 1864. | | 1865. | |
|---|---|---|---|---|---|---|
| | No. | Tons. | No. | Tons. | No. | Tons. |
| War Vessels | 1 | 1,246 | 3 | 11,900 | 1 | 4,200 |
| Paddle do. | 38 | 26,147 | 80 | 57,000 | 47 | 29,000 |
| Screws do. | 69 | 53,980 | 85 | 67,340 | 120 | 88,000 |
| Sailing vessels | 49 | 36,457 | 52 | 47,760 | 75 | 35,000 |
| Barges, &c. | 13 | 6,170 | — | — | 25 | 2,100 |
| | 170 | 124,000 | 220 | 184,000 | 267 | 158,300 |

| | 1866. | | 1867. | | 1868. | |
|---|---|---|---|---|---|---|
| | No. | Tons. | No. | Tons. | No. | Tons. |
| War Vessels | 1 | 4,173 | — | — | 8 | 5,384 |
| Paddle do. | 35 | 13,602 | 26 | 9,510 | 18 | 6,291 |
| Screws do. | 121 | 75,559 | 82 | 53,673 | 82 | 81,241 |
| Sailing vessels | 57 | 32,787 | 75 | 45,753 | 109 | 79,577 |
| Barges, &c. | 32 | 3,868 | 58 | 5,462 | 10 | 2,385 |
| | 247 | 129,989 | 241 | 114,598 | 227 | 174,978 |

### Orders on Hand.

| | 1867. | | 1868. | |
|---|---|---|---|---|
| | Ves. | Tons. | Ves. | Tons. |
| Gun Boats | 5 | 2,028 | — | — |
| Screw Armour Clads | 5 | 11,836 | 3 | 10,188 |
| Paddle Steamers | 11 | 4,778 | 3 | 1,914 |
| Screw do. | 57 | 61,791 | 57 | 70,600 |
| Steam Dredgers | 3 | 1,585 | — | — |
| Sailing Vessels (Iron) | 26 | 26,650 | 38 | 37,300 |
| Do. (Composite) | 12 | 5,221 | 9 | 7,400 |
| Do. (Wood) | 11 | 900 | 11 | 1,858 |
| Barges (Iron) | 2 | 332 | 2 | 140 |
| Total orders on hand, 1867 and 1868 | 130 | 115,124 | 123 | 129,400 |
| Total orders on hand, 1866 | ... | ... | 106 | 78,000 |
| Total orders on hand, 1865 | ... | ... | 180 | 130,000 |
| Total orders on hand, 1864 | ... | ... | 120 | 100,000 |

### Horse-Power of Engines.

| | Horse-Power. |
|---|---|
| Supplied to Vessels built on Clyde in 1861 | 16,500 |
| To be supplied to Vessels building and contracted for | 14,200 |

## TELEGRAPH EXTENSION.

The new year has opened with bright prospects for the extension of telegraphic communication throughout the world. A cable has recently been sent out from England which is to be laid between Australia and Tasmania, and it is expected that the line of communication between these two colonies will be completed about the middle of the year. About that time, probably, there will be an uninterupted system of telegraps between this country and Russia. Communication has been effected between Denmark and Bornholm, and when the complement of the extension—namely, the section between Barnholm and Libau is completed, it will be practicable to send messages from this country almost direct to Russia. The successful submergence of the cable from Bornholm to Libau has been prevented by the ice in the Baltic. The submergence of a cable between Peterhead, in Scotland, and Norway is also contemplated. Over and over again the defects of the existing system of telegraphic communication with India have been indicated. There is now some hope that, after a comparatively short time, the means of correspondence will be considerably improved. The Indo-European Telegraph Company propose erecting a two-wire overland route from Nordeney, on the Hanoverian coast, through Prussia and Russia, *viâ* the Black Sea, and thence on through Persia to Teheran, to join the existing lines. Another scheme for effecting the object to which we have referred is projected by the Anglo-Mediterranean Company, who contemplate the extension of the system completed last year to India, by the submergence of a cable from Suez by the Red Sea to Aden, and thence on to Bombay. That business sufficient to supply both lines would be forthcoming, provided they were efficiently worked, there is no reason to doubt, but the superiority of submarine cables to land lines passing through countries the inhabitants of which may, in a political complication, become hostile to England, is obvious. The laying of a cable from Cuba to Jamaica, and thence to Panama, has been lately proposed, we understand, to its prompt completion. It has doubtless been remarked by those who feel an interest in the subject of which we are speaking, that nearly all the interruptions from time to time in the Persian Gulf cable have occurred near the same spot. In order to reduce the chances of stoppage, alternative land lines have been erected, and very shortly the Tweed and the Calcutta will leave England with 500 miles of cable to duplicate the means of communication where the interruptions have been frequent. A few statistics regarding the number of miles of telegraphic cable manufactured in England in 1868 will afford some idea of the progress of telegraphy during the period specified:—For the Malta and Alexandria cable, 920 miles; for the Tasmanian and Australian line, 200 miles; for the Crown colonies, five miles; for the French Atlantic cable, about 700 miles; for the Baltic cable, 320 miles; for the Persian Gulf cable, 500 miles; for cables for Norway, Sweden, and Italy, 100 miles; for the Denmark and Newcastle cable, 340 miles; for the Cuba and Florida cable (with five miles of extra line), 119 miles; for the cable employed in changing the landing-place of the Zandvoort cable from Dunwich to Lowestoft, 33 miles; for the Isle of Man cable, two miles; making a total of considerably over 3,000 miles of cable manufactured within the limits of a year.

## HOWLISON'S RAILWAY SLEEPING BERTHS.

Although some further provision for the comfort of railway passengers on "through" or long journeys is a recognised necessity, and smoking compartments are now in use, yet still we are without the comfort of sleeping accommodation or lavatory arrangements. America has taken the lead in this respect, but with our shorter lines, their system is too costly and inapplicable, so that if anything is to be done to induce the railway companies to introduce sleeping accommodation, it must be both economical and applicable to the present construction of carriages, which have neither the width nor height of the American cars. So far as we see, the invention of Mr. Howlison seems to fulfil these requisites, and there should be no excuse for railway companies not transforming a few of their "through" passenger carriages so as to be capable of being used as sleeping and reclining carriages. This would undoubtedly prove of substantial advantage to them, as well as convenience to travellers, and thus increase the passenger traffic amongst a large class of persons who require such comfort to enable them to save time by travelling during the night.

Mr. Howlison's invention is simple, and consists in several arrangements of moveable sleeping or reclining stuffed berths, which are either made to slide vertically in grooves at their ends, or turn radially on hinges attached to the sides of the carriage, or to the partitions. They are set in any desired position above, and in addition to the usual seats, and so arranged, when not in use, to slide close up to each other at the roof of the carriage, or down on the floor, or made to form the seat during the day; or, when hinged, be made to fold close into the back partition. It is stated by the inventor that any compartment of a first, second, or third class carriage thus arranged could, in the course of five minutes, be made to comfortably accommodate six ladies or gentlemen with separate sleeping berths, fixed at their proper and respective distances apart, by simple and efficient fastenings.

Universal Exhibition at Vienna.—The Austrian Government has decided on organising a grand international exhibition at Vienna. The site to be devoted to the purpose is a large park, which will afford accommodation for a building with surrounding grounds on a very extensive scale. Full particulars will be available shortly.

## THE LATE MR. JOHN DICKINSON.

We of the present day, can form but a faint idea of what was the state of the paper manufacture, now so important a branch of industry in this country, even at so late a period as the commencement of the present century. Instead of paper being reeled off in webs several feet in width, and at the rate sometimes of upwards of a mile a hour in length, each sheet had at that time to be made separately on a mould by hand, and had then to be subjected to various subsequent processes before it was in a state fit for use. To obtain an uniform and continuous supply for any purpose was almost a matter of impossibility, and the necessity of applying machinery to this manufacture was beginning to be felt, while the success which had attended its introduction into the spinning and weaving industries gave encouragement of success. Yet the whole change from a system of manufacture almost mediæval in its rudeness was comprised within the lifetime and was in great measure effected by the exertions and ingenuity of the gentleman whose name we have placed at the head of this paragraph, and who was buried on the 18th ult., at Kensal-green. John Dickinson, eldest son of Captain Thomas Dickinson, R.N., was born on the 29th of March, 1782, and had, therefore, nearly completed his 87th year at the time of his decease. The intimacy subsisting between Captain Dickinson's family and Mr. Andrew Strahan, at that time the King's printer, influenced his future career as connected with the supply and manufacture of paper. On the expiration of his indentures he commenced business in Walbrook, and shortly after joined Mr. George Longman, brother of the late Mr. Longman, of Paternoster-row, and for some time M.P. for Maidstone, and carried on business with him, and subsequently with his nephew in the premises in the Old Bailey, so long associated with the name of Dickinson and Co. It was not, however, until the year 1806 that the first patent "for manufacturing paper of an indefinite length" was taken out by Henry Fourdrinier, and this was soon followed by Mr. Dickinson's patent of June 30, 1807, for machinery for cutting and planing paper thus made. Fourdinier's patent for the paper machine, was taken out in the same year; and it was about this time that Mr. Dickinson commenced his career as a paper manufacturer by the purchase of Apsley Mill, near Hemel Hempsted, to which in the course of time four other mills in Hertfordshire were added, two of them constructed and the water power for them created under his own superintendence. It was in 1807, before the commencement of the Peninsula campaigns, that he invented a new cannon-cartridge paper, made by mixing together linen and woollen rags in certain proportions, so that after the explosion it was prevented from retaining sparks of fire. In 1809 he patented machinery for the manufacture of paper by means of a cylinder covered with wire gauze and connected with an air pump—a form of machine which still remains in use. This was followed by other patents for the manufacture of finely-faced copper-plate paper by a sort of veneering process, and for a machine to cut cards, both of which were successful inventions, and the former especially tended much to increase his reputation. In 1829 he invented the process of introducing coloured threads into the body of paper at the instant of its manufacture which was again improved on in 1839. This preservative against forgery will have been noticed by holders of Exchequer bills, and many of us will remember it in the stamped envelopes which were issued by Government after the adoption of the penny postage system, in the introduction of which Dr. Dickinson had taken great interest. In 1832 we find him again patenting a knotter or strainer for cleaning pulp from impurities, and two years later applying magnets for the removal of any portions of iron that may happen to be in the pulp, and thus preventing ironmould in the paper. Besides these, he took out other patents for improvements, more or less important, in the manufacture of paper, almost up to the period of his finally retiring from business in 1857. Such is a brief outline of the principal inventions of Mr. Dickinson in connexion with the manufacture, of which he must be regarded as one of the founders, and of which he was for so many years the recognized chief.

## REVIEWS AND NOTICES OF NEW BOOKS.

*A Descriptive Treatise on Mathematical Drawing Instruments.* By William Ford Stanley, F.S.A., 5, Great Turnstile, Holborn.

We are glad to see that this useful treatise has reached its second edition. As the first edition was noticed in The Artizan of April, 1866, it only remains for us to say that several useful additions have been made to the work, such as descriptions of the engraver's tray, of an ingenious modification of the copying table, where the drawing to be copied may be laid horizontally, and one or two other labour-saving apparatus. The book, though small, is a very complete and handy *vade mecum* for the mechanical draughtsman. To the inexperienced draughtsman it will be found especially valuable, as a great aid towards choosing an instrument, best adapted for his purpose, and also in instructing him how to use the instrument when so obtained.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

The new steel manufactory established last March in Chicago, is, we learn from the Chicago *Railway Review,* in successful operation, having a capacity for turning 2,600lb. of steel daily, the steel being of excellent quality.

Trade with the United States.—The value of British produce and manufactures exported to the United States, including California, last year was £21,822,763, against £28,449,514 in 1866, and £15,344,392 in 1863. In the five years 1863-7, the increase was £6,481,311. The value of the principal articles of British produce exported in each of the years 1863 and 1867 respectively, was as follows:—Woollens, £3,439,199 and £3,590,681; iron, £2,107,427 and £3,298,289; cotton, £2,155,035 and £3,166,603; linens, £2,282,010 and £2,918,530; tin, £831,779 and £1,447,450; apparel and haberdashery, £800,902 and £972,245; soda, £356,574 and £801,746; hardware and cutlery, £349,447 and £719,269; earthenware and porcelain, £356,329 and £711,349; machinery, £50,037 and £336,484. The value of foreign and colonial produce and manufacture exported to the United States, included California, last year was £2,296,108, against £4,352,393 in 1863. This large decrease in the five years of £2,056,284 is chiefly owing to the falling off in the exports of cotton, wool, and hemp. The value of these exports in each of the years 1863, and 1867 was—raw cotton, £1,391,749 and £16,319; wool, £1,049,919 and £210,293; hemp, £74,441 and £14,311. The value of the imports from the United States, including California to the United Kingdom was £19,572,033 in 1863, and £41,045,272 last year showing the large increase in the five years of £21,473,239. The value of some of the principal articles imported in each of the years 1863 and 1867 was as follows:—Raw cotton, £644,138 and £25,721,079; corn, £7,433,491 and £6,723,963; cheese, £925,007 and £1,470,017; tobacco, unmanufactured, £1,536,145 and £1,079,005; bacon and hams, £2,411,771 and £727,627; lard, £996,675 and £586,324; oilseed cake, £258,013 and £473,602; petroleum, £658,632 and £364,675; tallow £524,554 and £321,095; rosin, £3,506 and £256,769; oil £324,207 and £567,749; skins and furs £201,691 and £231,637.

### NAVAL ENGINEERING.

The Government has ordered two armour plated turret ships—the *Abyssinia* and the *Magdala*—to be constructed for the defence of Bombay, both vessels being built from the same drawings and patterns as the *Cerberus.* The contract for building the *Abyssinia* has been taken by Messrs. Dudgeon, of Poplar, and that for the *Magdala* by the Thames Iron Shipbuilding Company, Blackwall.

The "Arethusa."—The unarmoured screw-frigate *Arethusa,* 35 guns, 3,141 tons, 500 horse-power, has been paid off at Sheerness. Her engines (Penn's) are said to be in excellent order, and very free from wear. It is not thought likely that the *Arethusa* will ever again be commissioned as a sea-going ship; indeed, there is a rumour that some of her timbers are so rotten that the cost of repairing her would be too great to incur, when measured by the results that would accrue.

In accordance with orders received from the Admiralty, an official trial of Lowe's patent marine propeller, which has been further improved by his daughter, Mrs. Vansittart, was made on the 6th ult, off the Maplin Sands. The propeller was fitted to the *Cadmus,* screw corvette, 21 guns, 1,466 tons, 400-horse power, under the personal superintendence of Mrs. Vansittart. The principal features of the propeller are—1st, less slip, giving an increased speed of vessel, and full backing power, 2d, greater steadiness, or absence of vibration; and (consequent upon these), 3d, a less consumption of fuel, and a reduction of the wear and tear of ship and machinery. The propeller, when viewed endwise, instead of forming portions of the thread of a screw, presents a curved line, curving in opposite directions from the centre to the edges of the blade. The trial was undoubtedly successful, the ship being quite free from vibration. It was a bold course on the part of the adaptress to risk the reputation of the invention by attaching the blades to a boss to which they had never been adapted before; but the result has enabled Mrs. Vansittart to fit the Griffiths' boss with the certainty of obtaining a very marked advance over all known screw propellers

### STEAM SHIPPING.

The Helvetia Screw Transport.—The *Helvetia* is a remarkably fine steamship, and started on her voyage for Alexandria with 1,800 tons of coals in her bunkers, more than enough to carry her out and back. Her main poop deck has an unbroken length of 360ft., 1,000 hammocks swing for the accommodation of troops below. A novel feature in the 'tween decks is the liberal use of pine-wood dust each time the decks are swept or cleaned. The fresh smell from the wood purifies the air, it is said, in an extraordinary degree on a voyage, and the dust itself becomes a valuable absorbent. The *Helvetia* has a gross tonnage of 3,330 tons. The nominal power of her engines is 350-horse.

The New Steamship Line through the Straits of Magellan.—Messrs. Randolph, Elder, and Co. have launched from their yard, near Glasgow, the *Magellan,* a screw of 3,000 tons builders' measurement, and 600 horse-power. The engines, which are being fitted by Messrs. Randolph, Elder, and Co., are constructed upon their patent compound principle. The *Magellan* has been built to the order of the Pacific Steam Navigation Company, and is intended for the company's direct mail line between Liverpool and Valparaiso. Messrs. Randolph, Elder, and Co. have on the stocks three other steamers of the same size for the same service. They are to be named respectively the *Patagonia,* the *Andes,* and the *Cordilleras.*

Trial Trip of the "Deccan."—The *Deccan* which is the most recent addition to the Peninsular and Oriental Company,s fleet, underwent an official trial in Stokes Bay on the 7th ult. This fine vessel was built and engined by Messrs. William Denny Brothers of Dumbarton; she closely approximates in size and burden to the *Himalaya.* Her principal dimensions are as follows:—Length between perpendiculars, 345ft.; breadth of beam, 42ft; depth of hold, 30½ft.; builders' measurement, 3,001; gross tonnage, 3,128. She is fitted with engines of 600 nominal horse-power (indicating 2,730 during trial), diameter of cylinders, 76in., and length of stroke, 4ft. She has a four-bladed propeller of 18ft. 10in, diameter, with a pitch of 27½ to 30½, weighing 12½ tons. Two runs at the measured mile showed the following results:—1st Run.—Steam 25lb.; vacuum 28in.; revolutions, 52; knots, 12,950. 2nd Run.—Steam, 25lb.; vacuum, 28in.; revolutions, 52; knots, 14·516, the true mean speed being 13·733 knots per hour. There was a light westerly breeze blowing at the time, and the sea perfectly smooth; barometer, 30·39. The total weight of coals, water, stores. &c., on board was 1,256 tons and the vessel's draught of water was 18ft. 5in. forward and 19ft. aft, the mean draught being 18ft. 8½in. The heating surface of the boilers is 12,504 square feet, firegrate surface 420 square feet, and condensing surface 5,864 square feet. On leaving Stokes Bay the *Deccan's* head was put to sea, and she ran round the Isle of Wight, steaming from the Warner Light (a stiff westerly breeze which was found to be blowing outside the Wight compelling her to run several miles out to sea) to the Needles in 2hrs. 35min. A sister ship to the *Deccan,* to be named the *Hindostan,* of 3,000 tons and 600-horse power, is building at Messrs. Day and Co.'s iron works at Southampton, and will be ready for sea in August.

Four steam canoes, constructed at La Seyne, near Toulon, for the mail service on the Canal of Suez, have been tried, accepted, and embarked on board the packet *Lèlémague* for conveyance to Alexandria. They are built of mahogany, and furnished with awning for the protection of passengers; two of them belong to M. de Lesseps' company, and two to the Viceroy of Egypt.

## TELEGRAPHIC ENGINEERING.

A Spanish Transatlantic Cable.—The Spanish Consul-General has announced that tenders for a submarine cable between the islands of Cuba, or Porto Rico, Canaries, and the coast of Spain in the port of Cadiz, or its neighbourhood will be received at the Colonial Office (Ministerio de Ultramar) Madrid, prior to the 1st of March next.

American Telegraphs.—A Bill is now before the United States Congress for transferring the telegraphs of the country to the Government. The telegraphic system in the United States is represented by more than 60,000 miles of line and 120,000 miles of wire. It equals nearly the combined systems of all the Continental Governments of Europe. During the current year it is estimated that it will transmit 13,000,000 messages, which, as far as present returns show, amount to nearly double the number of messages transmitted in 1866 by all the Governments of Europe. The arrangement under which the press of the United States is served by the telegraph is peculiar. There are local and general combinations of the press, which, separately or combined, operate under a co-operative system. News is gathered from all parts to common centres, whence it is distributed to all sections of the country. Under this arrangement the Western Union Telegraph Company, during 1868, delivered to the press of the United States more than 350,000,000 words of press matter, which, divided by 20, the unit of messages would make more messages than were transmitted by all the lines of Europe during the year, their compensation being in the neighbourhood of 8,000,000,dols and that of the American Company from the press being about 800,000 dols.

## RAILWAYS.

Nineteen per cent. of the original cost of the Belgian State railways has been repaid.

The Central Pacific Railroad is now built to the Humboldt river two hundred and fifty miles east of Sacramento.

The traffic receipts on the Mont Cenis Company's line for the week ending December 31st last amounted to 9,108f. 50c. for passengers, to 535f. 60c. for luggage, to 10,962f. 10c. for goods, and to 1,096f. 65c. for sundries—total, 21,702f. 85c. (£868). The total receipts from the 15th of June to the 31st of December last amounted to 535,589f. (£21,424).

## DOCKS, HARBOURS, BRIDGES.

The New Bridge at Niagara.—The new suspension-bridge which spans the Niagara River a short distance below the cataract has been completed so far that it is passable for foot passengers. This structure, though not so massive and capacious as that built a mile and a half below, is at once an object of marked interest. The width and depth of the chasm at this point rendered the construction of this work very difficult, and makes it an object of attraction as a scientific achievement in the art of engineering. The dimensions of the bridge are:—The span from rock to rock is 1,190ft.; the span between the centres of the towers is 1,268ft. The length of the suspended platform is 1,240ft.; Height above the surface of the river, 190ft. The length of the central portion resting on cables is 635ft. The length of the platform supported by stays and cables is 605ft. The deflection of cables at the centre—in summer, 91ft., and in winter 88ft., making the rise and fall of the bridge from changes of temperature, 3ft. The length of the cables between the points of suspension in medium temperature is 1,286ft. The length of the cables between anchorages is 1,828ft. Length of cables and anchors, 1,888ft. Height of towers above rock on Canada side, 105ft., and on American side, 100ft. Base of towers, 28ft. square, and top, 4ft. square. The surface of the rock on the American side is 5ft. above that on the Canada side. The height of the roadway above the rock on both sides is 7½ft. The depth of the anchor pits below the surface of the ground is 18ft., and the length of the anchor chains under the ground is 30ft. The anchors are set in solid rock on the Canada side, and in masonry on the American side. The width of the roadway between the parapets is 10ft., depth of side truss 6½ft., and height of parapet above floor 4½ft. The bridge is supported by two cables, composed of two wire ropes each, which contain respectively 133 No. 9 wires. The weight of these wire ropes per lineal foot is 90lb., and the diameter of the cable is 7in. The total weight of the suspended portion of the cables is 82 tons net. There are 48 stays, weighing 15 tons net. There are 52 guys connected with the bridge. The aggregate breaking strain of the cable is 1,680 tons net, and that of the stays 1,320 tons net, making the total supporting strength of the cables and stays 3,000 tons. The number of suspenders used is 480, with an aggregate strength of 4,800 tons. The weight of the suspended roadway, including weight of cables and stays, is 250 tons. The ordinary working load is 50 tons, and the *maximum* load is 100 tons; permanent and transitory load, 350 tons. The towers when completed will be covered with wood and corrugated iron, and in point of architectural beauty will be highly ornate, imparting to each terminus of the bridge an air of elegance and substantiality and rendering the whole an attraction among the beauties and wonders of that interesting locality. On the opening of another season, when the roadway will be completed, it will be available for carriages.

## APPLIED CHEMISTRY.

A new and elegant method for preparing nitrogen gas had been made known by a distinguished Italian chemist, Signor Massimo Levi. It consists in heating bichromate of ammonia in a retort; the salt is thus resolved into green oxide of chromium, water and nitrogen gas.

A Process of bleaching wood pulp has been made known by M. Orioli. He has recognised (1) that chloride of lime however little is excess, has a tendency to produce, a yellow tint; (2) that all the strong acids turn the paste red under the action of the sun, or in some time without sunlight, in the presence of moisture; (3) that the slightest trace of iron is sufficient to blacken the paste in a very short time. These objectionable results are obviated by the following mixture:—For 100 kilogrammes of wood pulp 800 grammes of oxalic are employed, this serving the double purpose of bleaching the colouring matter already oxidised and of neutralising the alkaline principles favourable to oxidation; 2 kilogs. of sulphate of alumina, perfectly free from iron, are added. The principal agent in this new bleaching process is the oxalic acid, the energetic action of which on vegetable colouring matters is well known. The sulphate of alumina added does not bleach of itself, but it forms with the colouring matter of the wood a nearly colourless lake, which enables the brilliancy of the product to be heightened.

## MINES, METALLURGY, &c.

Advices from Labuan give at length satisfactory prospects of the working of the coal mines at that island. After the break up of the China Steam and Labuan Coal Company the property was bought for a small sum by a few men of business in Scotland, and placed under an experienced manager, every precaution being taken for the exercise of rigid economy. The result appears to be that there is already a steady output of coal, and that attention is being paid at Singapore and elsewhere to its valuable peculiarities for steam and gas purposes. At the same time the working even on its present scale has been brought to yield a surplus over expenses. The latest accounts confirm the impression that the quantity available is practically inexhaustible.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 82 | 10 | 0 | 84 | 10 | 0 |
| Tough cake and tile do. | 81 | 10 | 0 | 82 | 0 | 0 |
| Sheathing and sheets do. | 85 | 10 | 0 | ,, | ,, | ,, |
| Bolts do. | 83 | 10 | 0 | ,, | ,, | ,, |
| Bottoms do. | 85 | 0 | 0 | 88 | 0 | 0 |
| Old (exchange) do. | 69 | 10 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 86 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7¼ | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 7 | ,, | ,, | ,, |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 5 | 0 | 20 | 10 | 0 |
| Do. to arrive | 20 | 10 | 0 | 20 | 12 | 6 |
| ZINC. | | | | | | |
| In sheets, per ton | 25 | 10 | 0 | 26 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 116 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 117 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 120 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 115 | 10 | 0 | ,, | ,, | ,, |
| Straits do. | 115 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 6 | 1 | 8 | 6 |
| IX. do. 1st quality do. | 1 | 12 | 6 | 1 | 14 | 6 |
| IC. do. 2nd quality do. | 1 | 5 | 6 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 11 | 6 | 1 | 12 | 6 |
| IC. Coke do. | 1 | 3 | 6 | 1 | 5 | 6 |
| IX. do. do | 1 | 9 | 6 | 1 | 11 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 12 | 6 | 6 | 15 | 6 |
| Do. to arrive do. | 6 | 10 | 0 | 6 | 12 | 0 |
| Nail rods do. | 7 | 0 | 0 | 7 | 2 | 6 |
| Stafford in London do. | 7 | 12 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 2 | 6 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 5 | 9 | 3 | 0 | 9 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 5 | 0 | 19 | 7 | 6 |
| Do. W.B. do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 0 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 22 | 10 | 6 |
| Spanish do. | 18 | 5 | 0 | 18 | 7 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated December 16th, 1868.

3826 L. Deseus—Miners' lamps
3827 R. Wappenstein and R. Ray—Registering the numbers of passengers travelling in or on omnibuses, &c.
3828 A. Clark—Inlaying metals
3829 J. Worrall and J. Kershaw—Improvements in drying stoves, &c.
3830 T. Aveling—Steam cultivation
3831 F. Ryland—Metallic lids for saucepans, &c.
3832 S. C. Lister—Steam boilers
3833 G. Ritchie—Compositions for woven fabrics, &c.
3834 S. C. Lister—Preparing wool, flax, and china grass, &c.

### Dated December 17th, 1868.

3835 J. T. Hall, G. Critchley, and H. B. Fox—Self-acting rack or catch
3836 J. Thorniley and G. B. Wing—Renewing worn-out files
3837 G. Hadfield—Varnish
3838 F. Robert Theurer—Watches
3839 A. Perry—Lighting stained or coloured windows
3840 W. H. Lennox, J. W. Pearman, and W. J. Pearman—Surfaces for printing music
3841 W. Manners—Irreversible passengers' railway danger signal
3842—G. H. Benson and W. G. Valentin—Iron and steel
3843—G. H. Benson and W. G. Valentin—Combustible gases
3844 T. Inglis and T. English—Improvements in tubes or cylinders
3845 F. H. Knevitt and H. Hazard—Shutters and blinds
3846 J. C. Walker—Acid powder for bread, &c.
3847 R. Hallimond—Lubricator
3848 J. Quick and J. Sampson—Pistons
3849 J. Pouncy—Photographic pictures

### Dated December 18th, 1868.

3850 C. Liebermann and C. Graebe—Colouring matters
3851 E. T. Hughes—Reducing the friction and assisting the flotation of vessels when passing through the water
3852 E. T. Hughes—Tea and coffee urns
3853 J. W. Brierley—Forging nuts
3854 W. F. Thomas—Sewing machines
3855 J. Hodgson H. Bottomley, and E. Cockroft—Weaving
3856 E. S. Griffiths—Carrying anchors inboard after being weighed
3857 T. B. Salter and J. Silvester—Pressure or steam gauges
3858 J. Edridge and J. Merrett—Tinning pins, &c.
3859 S. Remington—Shoe or breech piece for breech loading firearms
3860 D. Imhof—Improvements in chimes, &c.
3861 T. Spencer—Spinning silk, &c.
3862 G. D. Robinson—Carriages
3863 E. P. H. Vaughan—Rosin oil
3864 E. Pavy and J. Clark—Jute, china grass, cotton, &c.
3865 J. Petrie and W. T. Cheetham—Warming apartments
3866 M. Brown-Westhead and R. Smith—Thread or twine

### Dated December 19th, 1868.

3867 L. E. Leroy—A system of publicity
3868 J. Brierly—Ventilation of sewers and drains, &c.
3869 M. S. Maynard and R. Grime—Regulating speed of motive-power engines
3870 P. Spence—Alum, &c
3871 J. Jones—Drawing off vapours from baths employed in coating metals
3872 W. S. Thomson—Ladies' skirts
3873 J. Dickson—Windows
3874 G. H Asker—Umbrellas, &c.
3875 T. Warwick and A. Boyle—Testing stretchers and ribs of umbrellas

### Dated December 21st, 1868.

3876 W. R. Lake—Cutting and working rocks, &c.
3877 T. R. Shaw—Lubricating the bearings of shafting, journals, &c.
3878 W. F. Stanley—Exciting frictional electricity.
3879 R. Wilson—Cutting metals, &c.
3880 J. E. Massey—Taking soundings
3881 H G. Thompson—Carpets, &c.
3882 W Lewis—Ploughs for tilling land
3883 I. Baggs—Iron
3884 J. S. Walker—Undermining, "holeing," and cutting coal, &c.
3885 L. A. W. Lund and E. Axmann—Brooches, buttons, &c.
3886 E. A Cowper—Velocipedes
3887 R. Whitaker—Fastening or locks
3888 W. Pidding—Locomotion
3889 J. Wilkinson—Saddle cloths, &c.
3890 T. B. Hubbell—Bandage to be used by females
3891 J. H. Johnson—Sharpening and setting saws, &c.
3892 H. W. Hammond—Spring paul washer
3893 W. E. Gedge—Resinous bitumen
3894 P G. Jarre—Hydro-pneumatic pump.
3895 W. E. Gedge—Cock or tap
3896 J. Breeden—Taps or valves for liquids, gases, and vapours
3897 J. Clayton—Working the valves of steam and other engines
3898 G. Ritchie—Parasols, &c.
3899 W. R. Clark—Communicating between passengers and guard and engine driver of railway trains
3900 H. T. Vanner and E. Prest—Currying and dressing leather

### Dated December 22nd, 1868.

3901 L. J. Paine—Removable collars and comforters combined
3902 Captain J. Jensen—Reefing and unreefing the mainsail and jib of vessels
3903 W. Challiner—Stamping forks or spoons of steel, &c.
3904 J. Palmer—Steel agricultural and horticultural forks
3905 G. Tidcombe—Conducting paper from papermaking machinery, &c.
3906 J. H. Johnson—Sheaves or pulleys for hoisting and hauling tackle
3907 F. N. Gisborne—Apparatus for explosion of torpedoes, &c.
3908 S. Smart—Steam and other boilers
3909 F N. Gisborne—Apparatus for generating gas, &c.
3910 J. Snape—Pumps
3911 D. S. Price—Iron and steel
3912 A. Sezille—Improvements in treating corn for panification
3913 W. Clay—Forgings
3914 J. G. Jennings—Treating sewage
3915 B. Norton—Improvements in tipping pile fabrics
3916 W. E. Gedge—Floating docks

### Dated December 23rd, 1868.

3917 B. W. Maughan—Heating water
3918 E. M Thornton—Footstools, &c.
3919 G. M. Wolmershausen—Obtaining the form of the human figure.
3920 W. G. Reeve—Inkstands
3921 G Hookham—Sash lines, &c.
3922 G. Lowry—Ferrules for casks
3923 H. G Thompson—Figured terry
3924 J H. Johnson—Plates for artificial teeth
3925 W. E. Gedge—Bell-sounding apparatus
3926 F. P. Warren—Cooking apparatus
3927 J. W. Wilson—Hydraulic lifts
3928 A. V. Newton—Treating cod liver oil
3929 A. M. Clark—Gas burners

### Dated December 24th, 1868.

3930 W. H. Walenn—Electric deposition of copper and brass
3931 T. Warren—Glass furnaces
3932 J. H. Johnson—Transmission of telegraphic despatches
3933 W. R. Lake—Carriage boat
3934 C. D. Abel—Rolling mills
3935 H. Robinson and J. Smith—Dressing millstones
3936 R. Boby—Floors for malt kilns, &c.
3937 H. C. M. Turnbull—Working fans
3938 H. Clifford—Submarine telegraph cables
3939 W. H. Ridgway and F. W. Walker—Ornamental bricks, &c.
3940 A. C. Pilliner and J. C. Hill—Obtaining motive power
3941 G. T. Bousfield—Steam valves
3942 W. Ehrhardt—Watches
3943 H. Hillebrant—Repeating firearms

### Dated December 26th, 1868.

3944 C. E. Brooman—Portable lamp
3945 E. Butterworth—Furnaces
3946 C. Gordon—Breech loading firearms
3947 G. Eldridge and I. Smith—Closing casks
3948 J. P. Mills—Rest pins for pianofortes, harps, &c.
3949 A. S. Harington—Tobacco pouch
3950 W. R. Lake—Pegging boots
3951 H. Yorath—Elevating corn, &c.

### Dated December 29th 1868.

3952 C. D. Abel—Metal pipes
3953 J. A. A. Landa—Engraving letters on stone or metal
3954 A. Browne—Illuminating gas
3955 I. Pick—Travelling bags
3956 F. A. V. Michel—Printing surfaces
3957 J. Gillman—Contracting lever scale
3958 F. N. Gisborne—Giving motion to sewing machines
3959 G. T. Bousfield—Extracting matter of madder root
3960 G. Slater—Plaiting strips of cloth, &c.
3961 J. Marsh—Capping bottles
3962 R. Hughes and T. Hughes—Improvements in velocipedes

### Dated December 30th, 1868

3963 J. Laurie and J. Whittaker—Screwing and tapping
3964 S. Fox, W. Fox, J. Reffit, and G. Grange—Shaping wood
3965 A. G. Cazalut—Steel
3966 J. Hutcheson and A. Hutcheson—Improved elevator
3967 T. F. Henley—Lac dye
3968 J. H. Johnson—Paper tubes for the spinning of wool
3969 W. Winter—Sewing machines
3970 C. Monestier and I. Bang—Impermeable paper
3971 G. Davies—Separating ores
3972 P. Gornall and R. Gornall—Long collars of roving frames
3973 H. H. Bigg—Artificial legs
3974 E. T. Noualhier—Supplying and exhausting air
3975 J. Gedge—Gas fittings

### Dated December 31st, 1868.

3976 H. A. Bonneville—Drying malt
3977 C. de Bergue—Railway tramways
3978 W. E. Gedge—Novel sweetmeat
3979 W. R. Lake—Spinning machines
3980 W. R. Lake—Untwisting hair ropes
3981 F. A. K. W. Von Oppen—Breech loading firearms
3982 A. Barclay—Air pumps
3983 B. Samuelson—Iron and steel
3984 D. Spill—Xyloidine
3985 G. M. Weils—Wrenches
3986 H. E. Newton—Washing machines
3987 W. E. Newton—Firearms, &c.
3988 R. Griffiths—Propelling vessels
3989 T. Gibson—Railway buffers
3990 J. Seelig—Ventilation of hats
3991 C. Shales—Tatting shuttles

### Dated January 1st, 1869.

1 J. Heap—System of gearing
2 T. Singleton—Preparation of yarn
3 S. Lyons—Designs on textile fabrics
4 W. M. Williams—Lining puddling furnaces
5 G. Smith—Clipping horses, &c.
6 T. Green—Steam boilers
7 T. Green—Bushing bung holes
8 B. G. George—Show cards, &c.
9 F. Perry—Preserving animal and vegetable substances
10 M. Henry—Combing fibrous materials

### Dated January 2nd, 1869.

11 J. H. Johnson—Velocipedes
12 S. Smithson, G. Senior, and J. Inman—Taps and valves
13 A. Batchelar—Burning bricks, &c.
14 W. G Rawbone—Firearms
15 A. Carter and R. E. Grubb—Candlesticks
16 J. G. Tongue—Stitching volumes

### Dated January 4th, 1869.

17 M. Wolfsky—Fastenings for purses
18 H. A. Bonneville—Refining iron
19 W. A Biddell and J. Redgrave—Lamps
20 S. J. Peet—Valves
21 J. McKenny—Horses' shoes
22 J. Major, H. Trigg, and W. Wright—White lead

### Dated January 5th, 1869.

23 H. A. Bonneville—Coating with gold, &c.
24 L. Hannart—Printers' type
25 S. Bateman—Paddle wheels
26 W. Prosser—Purification of oils
27 E. W. Voce and J. Voce—Rotary fans
28 E. Fox—Iron and steel
29 J. J. Hays—Drying peat
30 J. Balbirnie—Inhaling vapours
31 J. H. Johnson—Sewing machines
32 A. Mason—Distillation of oils
33 G. Smith—Consumption of smoke
34 D. Nicoll—Clothing
35 W. Dawes—Steam engines
36 S. Remington—Firearms
37 A. W. C. Williams—Lawn mowers
38 J. Stevens—Plaiting linen

### Dated January 6th, 1869

39 H. L Vallee, H. A. Dourlet, and A. M. H. Armand—Artificial flowers
40 J. S. Gisborne—Mechanical telegraphs
41 E. Robbins—Tubular casts, &c.
42 K. Walter—Sulphuric acid
43 A. Tyler—Cossacks
44 W. Pidding—Treating plants, &c.

### Dated January 7th, 1869.

45 G. Eveleigh—Gas
46 J. Mansergh—Stench traps
47 J. F. Cooke—Copying ink
48 H. Davey—Raising water
49 F. N. Gisborne—Giving motion to sewing machines
50 F. R. A. Glover—Weighing anchors
51 J. H. Johnson—Concentrated food cakes
52 W. Webster—Treating jute, &c.
53 J. J. Bodmer—Iron and steel
54 H. G. Fairburn—Compressing coal, &c.
55 C. Kendall—Communication between guard and passengers

### Dated January 8th, 1869.

56 J. Mangnall—Preparing coffee
57 W. Tatham—Preparing cotton
58 T. P. Lucas and G. H. J. Holt—Exhibiting cartes de visite
59 J. Daglish—Lubricating the axles of coal tubs, &c.
60 R. Wigram—Horse ploughs
61 A. B. Brown—Raising weights, &c.
62 W. T. Waite—Treatment of saccharine matters
63 T. B. Sydserff—Ballot voting apparatus
64 J. Rodgers—Saw hardening furnace
65 M. Wilkin and J. Clark—Railway breaks
66 J. Henderson—Iron and steel

### Dated January 9th, 1869.

67 W. E. Gedge—Improved boxes for preserving provisions
68 R. Legg—Application of steam
69 F. S. Thomas—Railway carriages
70 M. Saunders and H. Forrest—Refrigerators
71 E. Gray—Plough coulters
72 T. Moore—Rotary engines

### Dated January 11th, 1869.

73 A. Baumann—Travelling cranes
74 J. Holding—Temples for looms
75 F. N. Gisborne and H. Allman—Signals on railway trains
76 J. Knowles—Weaving terry
77 J. Jordan and J. Jordan—Propelling vessels
78 T. A Warrington—Clips for window blinds and rollers
79 J. B. Palmer—Sight protectors for firearms
80 J. Petrie, jun.—Washing wool
81 W. H. Penning—Signalling
82 C. W. Spong—Railway carriages
83 J H. Johnson—Boxes from paper pulp
84 F. C Matthews—Treating Indian corn
85 C. Newsome—Milk cans

### Dated January 12th, 1869.

86 C. McDougall and C. H. Eden—Ladies' umbrella. &c.
87 W. E. Gedge—Power looms
88 A. Henry—Firearms
89 A. P. Price—Production of colours from naphthaline
90 B. Hunt—Water meters
91 Sir F. Sykes—Defending ships.
92 A. V Newton—Knitting machinery
93 D L. Coates, Q. Dunlop, and W. Orr—Couplings and wheels for shafting
94 C. E. Brooman—Velocipedes
95 G. V. Osborne and A. J. Peerless—Improved ball valve

### Dated January 13th, 1869.

96 H. Aitken—Lamps
97 S. Jellymann—Reaping machines
98 C. J. Gunther—Preserving meat
99 P. M. Barnett—Securing wooden keys in railway chairs
100 J. Steel—Substitute for waterclosets
101 L. Sterne, J. A. Jaques, and J. A. Fanshawe—Elastic rubbers
102 J. Parker—Propelling vessels
103 L. Hannart—Mould for wheels requiring to have letters
104 J. Schlosser—Metallic packing for steam engines, &c.
105 W. R. Lake—Uniting ends of tubes
106 C. P. Coles—Protecting bottoms of ships

### Dated January 14th, 1869.

107 G. D. Kittoe and P. Brotherhood—Improved valves
108 W. McDonnell—Churns
109 R. Watson and B. Dangerfield—Improvements in chronographs
110 J. R. Hodgson—Life buoys, &c.
111 T. Mortlock—Dressing millstones
112 E. P. North—Improved pocket railway reading lamps
113 H. Vavasseur and C. M. Wade—Permanent way of railways
114 A. V. Newton—Reaping
115 W. E. Newton—Improved regulator for steam pumps
116 J. H. Kitson and J. Kirby—Moveable grates for steam boiler furnaces
117 T. Cook and J. Watson—Improvements for expressing oils
118 A. M. Clark—Firearms
119 T. Birkett—Firearms

### Dated January 15th, 1869.

120 H. L. Harris—Packing cases
121 C. H. Lea—Opening and locking railway level crossing gates
122 J. Steel—Washing casks
123 A. de P. Chance—Step ladders
124 J. T. Smith—Converting vessels used in the manufacture of iron
125 H. Fowkes—Cleaning gun barrels
126 D. P. Wright—Improved furniture for window blinds
127 W. Tijou and W. Whieldon—Facilitating the getting of coal, &c.
128 A. Sebet—Improvements in breech loading firearms
129 W. H. Brookes—Fastener for doors
130 P. Spence—Sulphate of potash
131 T. Howcroft and A. McGregor—Reaping and mowing machines
132 E. Craddock—Punching metals
133 M. Boyce—Scoring at whist, &c.
134 A. H. A. Durant—Oil from seeds

### Dated January 16th, 1869.

135 T. A. Warrington—Spoons
136 J. T. Bintley—Joining the ends of rails
137 S. Russell—Velocipedes
138 R. Craig—Paper
139 J. Jeavons and W. Waplinton—Iron and steel
140 J. G. Johnson—Self-acting signalling apparatus
141 J. H. Johnson—Casks
142 H. A. Silver—Cooking apparatus
143 J. Bourne—Propelling vessels
144 J. Loader and W. H. Child—Improved steam boilers
145 W. Bottomley and S. Bottomley—Couplings of rollers for cotton, &c.
146 W. Thomas—Boots and shoes
147 J. B. Whitehall—Improved apparatus for looped fabrics
148 F. Brady—Sulphate of ammonia
149 L. B. Phillips—Metal fac-similes of works of art
150 W. R Lake—Figured shawls
151 M. Henry—Moulding metal articles

### Dated January 18th, 1869.

152 W. Pidding—Cut piled mosaic fabrics
153 W. H. Platt—Looms
154 N. Voice—Apparatus for closets, etc.
155 C. Catlow—Looms
156 J. D. Thomas—Artificial bust
157 P. Oldfield—Combing wool
158 R. H. Clarke—Silk cloths
159 G. R. Postlethwaite—Screw nuts, etc.
160 J. W. Price—Horse-shoe nails
161 W. R. Lake—Propelling canal boats
162 G. Brown—Gas meters
163 J. H. Johnson—Burning bricks
164 A. M. Clark—Refining sugar
165 H. H. and J. Parnall—Scales
166 W. T. Eley—Cartridge cases
1

# REIGERS' IMPROVED GOVERNOR.

FIG. 1.

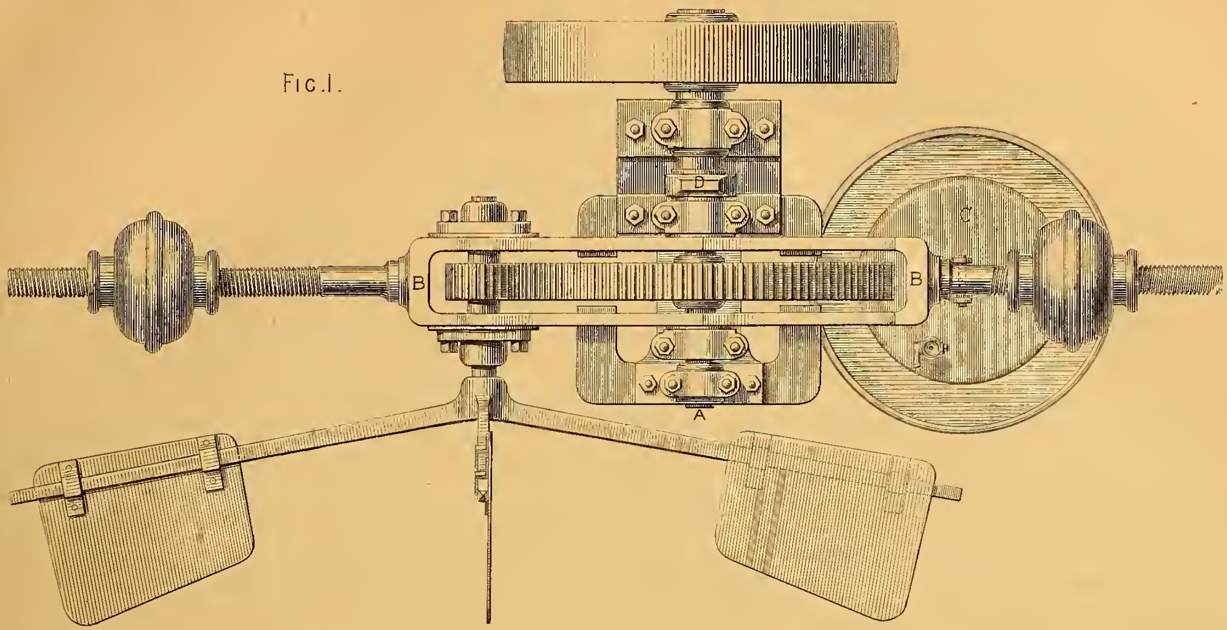


FIG. 2.

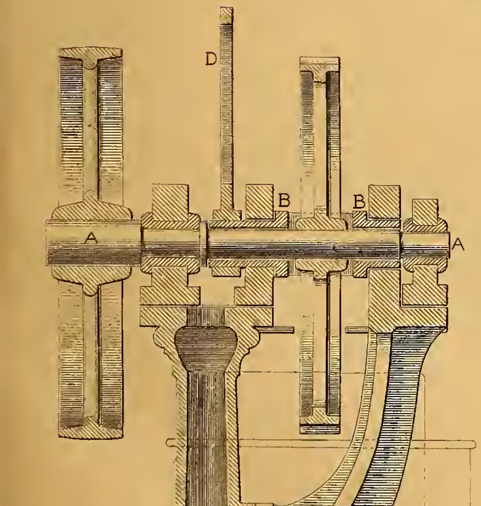
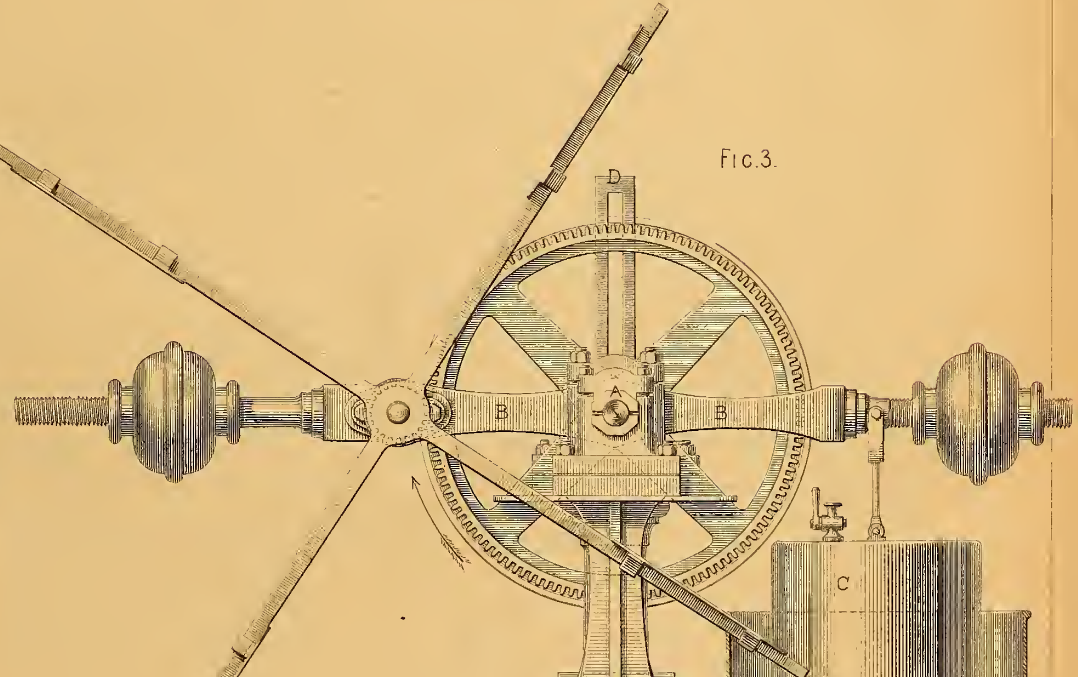


FIG. 3.



W. Smith, C.E. direx.

# THE ARTIZAN.

No. 3.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. MARCH, 1869.

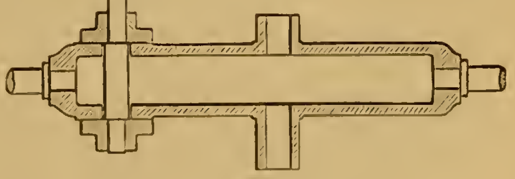
## REIGERS' IMPROVED GOVERNOR.

*(Illustrated by Plate* 342).

It is astonishing to find what a difficulty there seems to be in obtaining a really good governor for a steam engine. In the former construction of beam engines with a long stroke and a very moderate speed of piston, the old style of governor was sufficiently effective for nearly all practical purposes. In fact, since Watt applied this governor for regulating the engines of the Albion Mills more than eighty years ago, it was, we may say, universally adopted until quite lately, and even now is by far the most common form of governor. Not but what many different kinds of governors have from time to time been proposed, as the curious examples given in the first edition of Tredgold, published some forty years ago, bear witness, but not one of them or of the many others invented, has been able to compete with that designed by Watt, both in practical efficiency and in mechanical simplicity. As, however, the pressure of steam, and the speed of the piston, gradually increased, and the advantage of expansion became more generally understood, the inherent defects of this description of governor became more apparent; while at the same time the greater delicacy of the machinery to be driven as in spinning mills, or the extreme variation in the power required to be exerted as in saw mills, made these defects still more visible. To meet these exigencies, Mr. Siemens designed his ingenious chronometric governor which, as its name implies, is furnished with an independent clock movement, having a weight and pendulum. The clock movement causes a bevel wheel to revolve at a uniform speed, and another bevel wheel with the same number of teeth and situated on the same axis, is carried round by the engine in an opposite direction. A bevel pinion at the end of a crank arm gears with both wheels, similar to a differential motion, and to this crank a rod communicating with the throttle valve is attached. When both the bevel wheels are moving at the same speed the pinion remains stationary, but if one wheel travels faster than the other the crank to which the pinion is attached, will be carried round upon its axis and will thereby move the throttle valve. This governor regulates the speed of an engine remarkably well, being exceedingly delicate and very quick in its action. A variation during only a portion of a revolution being sufficient to bring it into action. Like many other beautiful inventions, however, it is very expensive, and consequently is not very generally used, besides which it is only suited to large engines.

Another form of governor which, though not so perfect in its action as that just described, has come into considerable favour during the last few years in consequence of its simplicity. It is, we believe, of American origin, and may be considered as a modification of the Watt governor. The governor balls are considerably smaller, but revolve at a high velocity, and are regulated by a weight which slides on the spindle. The usual velocity at which the balls revolve is so great—from 300 to 400 revolutions per minute—that a central weight of one or two hundred pounds is required to balance the contrifugal force of balls weighing only two or three pounds. This governor, of course, is open to the same objection in principle as the ordinary Watt governor, viz., that it can only regulate the engine for a variation of load by maintaining a corresponding change of velocity in the engine; but as the number of revolutions of the governor greatly exceed those of the engine, so any variation of speed in the engine is magnified by the governor. The action is thus rendered so much more sensitive and extended than in the ordinary governor, that these objections are very much reduced, and are said to be almost imperceptible.

A new form of governor has lately been invented by Mr. Reigers, and is illustrated in Plate 342, Fig. 1 being a plan, Fig. 2 a sectional elevation, and Fig. 3 a side elevation. This arrangement is very different from the usual description, and is based upon the following principle:—Suppose an axis is put in rotation by a pair of wheels, the power which causes the rotation acts in two directions; first, it turns the axis, and secondly, it tends to move the axis in the direction of rotation. Upon referring to the Plate (342), it will be seen that the whole mechanism is mounted upon a column which carries a plate supporting two small bearings. To one side of the column is fitted a bracket carrying another plate, which also supports two bearings. These bearings have all a common centre line, the two outer bearings carrying the revolving spindle, A, upon which is keyed the spur wheel, and the two inner bearings supporting the horizontal lever, B, which carries the pinion. The lever B is provided with weights at each end, which may be adjusted to any distance from the fulcrum, by means of the screws cut on each end. The governor is driven in the usual manner by a strap running over a pulley on the crank shaft, and also over a pulley on the spindle (A) of the spur wheel. Upon first starting, as the spur wheel is moved, the vane or flier fitted on the same spindle as the pinion, is caused to revolve with great rapidity, when, owing to the resistance of the air a certain pressure is imparted to the the teeth of the pinion in the direction of the arrow (Fig. 3), and tending to raise that end of the lever. To regulate the motion of this lever (B) a float, C, is attached to it at the other side of the fulcrum. This float is partially immersed in water, and has a small air cock fitted on the top so that air can be either blown out or sucked in according to the varying height of the float in the water. This float prevents too great sensibility of the governor. The counter weights upon each end of the lever are then regulated by hand until the lever stands horizontally, when the engine is running at its normal speed. The fulcrum of the lever B rests in bearings, and is hollow to allow the spindle (A) of the spur wheel so revolve independently, as shown in Fig. 2, and in the annexed woodcut, which represents a horizontal sectional plan of the lever. In order to actuate the throttle valve, one side of the lever is elongated and carries a vertical arm, D, upon it. This arm is connected in the usual way with the throttle valve, the amount of throw being capable of variation by means of a slot, as shown in Figs. 2 and 3.



The great novelty of this invention seems to be in the air vessel or float, which is said to regulate, with the greatest nicety, the motion of the engine.

It has been in use for some time in Holland, whence a correspondent forwards the following account of some experiments that were made to test its efficiency upon an 8 horse-power engine :—

| No. | Expansion. | Condension. | Amount of Load. | Revolutions. |
|---|---|---|---|---|
| 1 | ¾ | with | 3 lathes, 1 planing machine, 1 grindstone, 1 cyl. blower ........................ | 45 |
| 2 | ½ | „ | Same as above........................................ | 45 |
| 3 | ½ | without | 1 boring machine, 1 screw-cutting do., in addition ........................................ | 45 |
| 4 | ½ | „ | Only the blower, without any pressure ...... | 45 |
| 5 | ½ | „ | Same as No. 3........................................ | 45 |
| 6 | ½ | „ | „ No. 4........................................ | 45 |
| 7 | none. | „ | „ No. 3........................................ | 45 |
| 8 | „ | „ | „ No. 4........................................ | 45 |

These experiments show that whatever the variations in the conditions under which the engine was placod, there was absolutely no variation in the speed—a remarkably favourable result, and one which we would suggest, deserves the attention of engineers.

## H.M.S. "HERCULES."

Abouc ten years ago the committee on steam-ship performance appointed by the British Association, recommendod for the purpose of more correctly ascertaining the true merits of steam vessels, that they should be tried for a uniform distance at sea, instead of, or in addition to the usual run over the measured mile. They remarked that "the return of particulars of performances at sea will afford the means of making such comparisons with smooth water performances, as cannot fail to throw light upon qualities of vessels, which as yet are a matter of speculation only." The Government authorities were, however, slow to perceive the advantages of an ocean trial, and the committee repeated their conviction, "That it would tend to the advancement of science, the improvement of both vessels and engines, and to the advantage of Her Majesty's service, if the trials of the Queen's ships were conducted on a more comprehensive plan, directed to definite objects of practical utility, on a scientific basis, recorded in a uniform manner." This recommendation has lately been partially followed, by the adoption the six hours' trial, though it is evident that the time is very much too short for anything like a thorough test.

In the six hours' trial of the *Hercules*, which took place on the 5th ult., nothing was omitted that could possibly depreciate its value, either for comparison with the similar trials of other ships, or as a test of the merits of the vessel itself. Thus, instead of running over the somewhat tortuous course taken by the *Warrior*, *Minotaur*, and *Bellerophon*, where these ships had to encounter the set of the tide in almost every direction, the *Hercules* was steamed out into a position south of the Nab, and clear of the local tides, before starting on her trial. From here she had a straight run south of the Isle of Wight to Portland Bill, assisted by tho whole strength of the tide running down Channel. After this manœuvre it might be expected that the ship would have been put through the trial in the usual manner, but it seems the "authorities" were not yet satisfied, the instructions on the present occasion being to "measure the distance run by the revolutions of the engine, taking the mean number of revolutions made in the six runs over the measured mile on the ship's speed trials there on the 4th Jan., as a divisor—to ignore tide in calculation of distance, and to take account of coal burnt." What a brilliant idea that was, to take for granted that the vessel would be propelled for the same number of revolutions an equal distance at sea as in still water! The simplicity of it is delightful; no more patent logs will be required, and captains will in future only have to look at the engine counter to know where they are.

The average speed of the *Hercules* was by these means calculated at 13·345 knots, but it is evident that this trial was perfectly useless, so far as regards the performance of the vessel, and only of value in estimating the merits of the engines. These, though not exerting the enormous power given out by them on the first trial, still proved themselves the most powerful engines ever made, the average indicated horse-power being 7184·7. The consumption of coal was exceedingly low, averaging 2·531bs. per horse-power per hour. The following are some of the particulars of the trial:—

*Outward Three Hours' Steaming.*

End of first half-hour.—Steam pressure in engine-room, 24lb.; vacuum forward, 28·5in.; aft, 27in. Revolutions of engines, half-hour, 1968; rate per minute, 65·6; total made, 1968. Distance run by the ship, by engines' revolutions, 6·513. Indicated horse-power, 7530·49.

Second half-hour.—Steam pressure in engine-room, 24lb.; vacuum—forward, 28·6in.; aft, 27in. Revolutions of engines—half-hour, 1961; total made, 3929; rate per minute, 65·36. Distance run by the ship, by engines' revolutions, 13·009 knots. Indicated horse-power, 7113·17.

Third half-hour.—Steam pressure in engine-room, 22lb.; vacuum—forward, 28·5in.; aft, 27·5. Revolution of engines, half-hour, 2106; total made, 6035; rate per minute, 70·2. Distance run by the ship, by engines' revolutions, 19·979. Indicated horse-power, 7577·12.

Fourth half-hour.—Steam pressure in engine-room, 23·5lb.; vacuum—forward, 27·5in.; aft, 28in. Revolutions of engines, half-hour, 2038; total made, 8073; rate per minute, 67·93. Distance run by the ship by engines' revolutions, 26·74 knots. Indicated horse-power, 7352·35.

Fifth half-hour.—Steam pressure in engine-room, 22lb.; vacuum—forward, 27in.; aft, 28in. Revolutions of engines, half-hour, 2023; total made, 10,096; rate per minute, 67·43. Distance run by the ship, by engines' revolutions, 33·433. Indicated horse-power, 6966·5.

Sixth half-hour.—Steam pressure in engine-room, 24lb.; vacuum—forward, 28in.; aft, 27in. Revolutions of engines, half-hour, 1978; total made, 12,074; rate per minute, 65·93. Distance run by the ship, by engines' revolutions, 39·980 knots. Indicated horse-power, 7283·33.

*Homeward Three Hours' Steaming.*

Seventh half-hour of steaming.—Steam-pressure in engine-room, 21lb.; vacuum forward, 28·5in.; aft, 27·5in. Revolutions of engines, half-hour, 2006; total made, 14,140; rate per minute, 68·86. Distanco run by the ship, by engine's revolutions, 46·833. Indicated horse-power, 7247·70.

Eighth half-hour.—Steam pressure in engine-room, 21lb.; vacuum—forward, 28·5in.; aft, 27·5in. Revolutions of engines, half-hour, 1956; total made, 16·096; rate per minute, 65·2. Distance run by ship, by engines' revolutions, 53·29 knots. Indicated horse-power, 6881·91.

Ninth half-hour.—Steam-pressure in engine-room, 21·5lb.; vacuum—forward, 28·5in.; aft, 27in. Revolutions of engines, half-hour, 2098; total made, 18,194; rate per minute, 69·93. Distance run by ship, by engines' revolutions, 60·24 knots.

Tenth half-hour.—Steam pressure in engine-room, 23lb.; vacuum—forward, 28·5in.; aft, 26·5in. Revolutions of engines, half-hour, 1946; total made, 20,140; rate per minute, 64·86. Distance run by ship, by engines revolutions, 68·873 knots.

Eleventh half-hour.—Steam pressure in engine-room, 22·5lb.; vacuum—forward, 28·5in.; aft, 27in. Revolutions of engines, half-hour, 2092; total made, 22,232; rate per minuie, 69·73. Distance run by ship, by engines revolutions, 75·793 knots.

Twelfth and last half-hour.—Steam pressure in engine-rooms, 24lb.; vacuum—forward, 28·5in.; aft, 26·5in. Revolutions of engines, half-hour 1956; total made, 24·188. Distance run by ship, by engines' revolutions, 82·263 knots.

Deducting 2·193 knots from the total distance run, to meot an error in calculation, the exact distance run by the ship in the six hours was 80·070 knots. It must be remembered, however, that in measuring the distance gone by the ship in the six hours' steaming it has been assumed that the conditions must be the same as they were at the measured mile, which they were not; and that no allowance has been made for the slip of the screw or for tide. The conditions of wind and sea disturbance can, indeed, never be met with sufficiently alike in a landlocked position such as the measured mile course in Stokes Bay, and a course between two headlands out in the Channel to furnish a true measure in the latter case of a ship's speed by the revolutions of her engines and screw.

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## ON SUGAR.

### BY MR. W. EATHORNE GILL.

The difficulties which are encountered in the manufacture of sugar are mainly due to the different components of the juice, which come into an active state of antagonism to—and positive destruction of—sugar, when expressed from the cane, involving the loss of more sugar than is sold. The record of the attempts to overcome such difficulties, reveals some shrewd guesses. Science proffered one solitary success, obtained by means of a poison, and consequently tabooed in practice. It is necessary to know the character of those difficulties which occur in the manufacture of sugar before the most suitable remedy can be appreciated. We can only glance at a few of these antagonists now.

At the very outset we encounter the fact, which is patent to all, that fermentation of the juice begins with its expression from the cane, and ultimately ends in acetic acid. Of course, all the juice is not permitted to run into acid, therefore, the acid present, be it more or less, is neutralised by lime, to be removed afterwards by the refiner. Whatever lime can accomplish in the juice more than this neutralization of the acetic acid, is positive destruction of sugar. Its ability to "defecate," or clear the juice, is a French notion, which some adopted to their loss of sugar.

To return to the fact that the juice ferments from the moment it is expressed, so also it is a well-known fact that a pure solution of sugar will not ferment until after some foreign matter has been introduced; we are thus led to infer that the cane-juice is not a pure solution, and that it either brings with it the seeds of destruction, or those seeds are introduced subsequently; and both these views may apply; for we find the albuminoids are contained in the saccharine juice, and the wooden trough, through which this juice flows from the mill to the receiver, becomes saturated with acetic acid, to innoculate whatever juice can come in contact with it. The juice now remains in the receiver until full. So, then, the juice has flowed over or through some 50ft., or it may be 150ft., of contamination to repose a few minutes longer in the receiver, and time affords the opportunity for perfecting the work of destruction, unless shortened by passing the juice on to the boiling-pans, where another chymical action is set up, aided by lime, and we get carbonic acid gas, and again to the destruction of sugar.

Another source of acetification is the saturated *débris* of the cane in the juice, or accumulating in the wooden trough, oxidised at every evolution, or change of position. It is a questionable improvement to arrest the *débris* at the mill; for where the atmosphere can get access to such *débris*, there fermentation will become more or less rife. It cannot be desirable to filter the juice through such a mass of contamination.

This fact may some day become an invitation for an improved sugar-mill, instead of that which the makers are content to perpetuate until a better mill is inquired for. The French remedy consisted of five rolls, instead of three, thus advancing in a wrong direction; of course it was a failure. But the notable proximate cause of fermentation is albumen, and another of similar ability which may have remained unnoticed by reason of its physical insignificance, whilst its power for destruction of sugar, by promptly inducing fermentation, is as insidious as it is immense; yet, hitherto, only suspected in relation to the subject before us—at least in practice. These "granules," as they have been termed, are found to be animate. Analysis had detected nitrogen in the juice, which excited the suspicion of animal matter, and when the cane was submitted to destructive distillation, the amount of ammonia strengthened the suspicion. Science gave us the empiric formulæ C. 10 H. 31, Az. 5, O. 12, and designated it proteine, and advised us of its proneness to ferment with sugar and promptly induce putrifaction. These granules passed into the hands of microscopists, who found the globules had a diameter of 3 to 5 milliemes of a millimetre, and that they have a tough, translucent skin, containing a semi-fluid matter. We can separate them by filtration; and the juice, when so treated, loses its lactescent character, and affords a perfectly limpid liquor, and may remain many hours without the slightest indication of fermenting. The organic matters in the juice, other than sugar, have been estimated by M. Icery, of L'ile Maurice Reunion, at 3·5 thousandths of the weight of the juice. *This proportion, however, augments with the pressure which expresses the juice.* The relative proportion which this most careful observer, and truly practical manipulator, assigns to each is:—

| | |
|---|---|
| Granular globules | 0·287 |
| Albumen | 0·076 |
| Other organic substances | 0·637 |
| | 1·000 |

M. Icery also estimates the mineral portion of the juice at 2·9 per 1,000. M. Payen give us the following as the results of his analysis of the juice of the sugar-cane; at the same time admonishing us with the significant hint that his figures cannot be constants, when climate, soil, or cultivation, can affect the various results:—

| | |
|---|---|
| Sugar | 18·00 |
| Ligneous matters, and pectic acid | 9·56 |
| Albumen, and three other nitrogenous matters | 0·55 |
| Fatty matters, oils, resins, aromatic, and deliquescent, &c. | 0·37 |
| Insoluble salts 0.12, and soluble 0·16 | 0·28 |
| Silica | 0·20 |
| Water | 71·04 |
| | 100·00 |

It will be seen here that the granules, to which we have been alluding, were then held deserving of no distinctive notice, yet are probably included in the comprehensive expression of "three other nitrogenous matters." Their importance commands more distinct attention since the discovery of the part they play.

In practice, the albumen has been, for the most part, coagulated by the boiling temperature to which the juice has been necessarily subjected, and the scum duly removed, yet there remained a complex organic matter, precipitable by alcohol, and by neutral acetate of lead, very soluble in the alkalies, and also in acids, including the tannic acid. Isolated and purified in many precipitations by alcohol, this substance is without odour or taste. It is white, amorphous, and now without action in polarised light, giving off ammonia when heated with lime or potash, deliquescent, and not redissolved after isolation. Immersed in water, it forms a viscid solution, mixed with sugar and water, and again it becomes equally viscid. This matter escapes those agents hitherto employed to purify the juice, and accumulates in the liquor, as evaporation removes the aqueous portion. It is found again in the sirops made with these sugar-products. We thus accumulate facts, which are inconsistent with our knowledge of albumen, and further experiments lead to the conclusion that we have here the principal opposing cause to the crystallisation of sugar. The well-known albumen and the matter coagulable by alcohol, equally promote the fermentation of the juice, but not with the same degree of energy.

Hassell found the insects *acari* in 35 out of 36 raw sugars, also sporules and filaments of fungi in 10, grape-sugar in all, and often to a considerale amount, and all contained a varying amount of albumen.

We are indebted to Robert Brown, the botanist, for the discovery, and to M. Le Rique de Mouchy and Professor Bechamp for their decisive observations of the extremely minute corpuscles. These microscopists at once detected an oscillatory movement, too formal to be accidental. Eventually they accumulated evidence sufficient to decide that these minute globules are animaculæs, and that they are met with, not only in the liquids of plants, but also in those of animals, in the polen of certain vegetables, in the eggs of butterflies, the liquids of caterpillars, spiders, &c. Also, that these "granules" are organized beings, probably some of the most minute hitherto discovered, and that *they act like a ferment.* Extracted from the cambium of geraniums, lilacs, &c., *they cause sugar and starch to ferment easily.* The physiological functions of these curious little bodies appear to reside in the maturation of fruit and of the sugar-cane, also in the elaboration and regeneration of tissues.

We have now traced out a hitherto unappreciated and most subtle cause of fermentation, and of the non-crystallisation of raw sugar, and seen how filtration can separate these animaculæ and keep back albuminous matter also. The difficulty occurs and is formidable whenever we attempt to carry out this filtration into practice. The question again presents itself, by what practical process can we secure the desired result? Lime has been misnamed a defecator, and I have made better and more sugar from a quantity of juice without lime than others did with it. Of course we *must* use lime when we permit the juice to ferment. "The concretor" gets rid of many difficulties where properly applied, but it does not produce "a grocer's sugar" fit for the consumer. In a word, the great requirement is, an efficient check on the destruction of sugar in its process of manufacture, such a check as cannot interfere with the economy of manufacture or the purity of sugar. There are also numerous panaceas, known by various names, as the endosmose and exosmose, the diffusion process, &c. They are not novelties, but mere *rechauffés*, which lost their attractiveness in practice.

I was several years on the island of Lurzon, and often on those other sugar-growing islands which compose that archipelago, of which Manilla is the capital. Consulted by the planters, I heard their complaints of the great loss of sugar, in its manufacture and the great difficulty appeared to me to be to neutralise the cause, by isolating the contained albumen of the juice, together with its congeners, and that with promptitude, having a due regard to the economy of manufacture.

The remembrance of a rather singular fact came to my help. It happened when I was in California, in 1852. I found many Chinamen had preceded me there, and some of them had died, and were buried. The love of home is strong in the Chinese, and they derive much assurance that they shall not remain in a strange land. In the fulfilment of such promises, exhumations were going on, which attracted the attention of some Americans, who had buried a friend in that immediate locality. They "concluded that the Chinese were not too particular," and might have included the remains of their friend amongst those exhumed. Such an offence the Americans were only too ready to resent. Knowing the precise spot, they found the corpse, to their utter astonishment, more plump, and the tissues firmer than when buried some months before. In a word, decomposition had been arrested on interment, and a complete change into adipocere was the consequence. I carefully studied the geological character of that cemetery, which alone could have produced this effect, and now conceived that it might involve an approach to success, in relation to the object which I had in view, namely, the coagulation of the albuminoids contained in the cane-juice; for, once coagulated, their ability to induce fermentation is at an end.

Experiment gratified my expectation, and experience on one occasion with a stone mill, rejected canes and adventitious appliances confirmed it: but my first efforts were too crude for repetition in practice, and I left before I had perfected my design, As it was, I got a certified increase of product amounting to 25 per cent. of well crystallised sugar of superior quality, by the aid of their own mills and evaporating pans.

Although it may be rare, still this change into adipocere is not singular The fact of this preservation is well known in Spain, and a worthy padre assured me he had seen it himself, and his description enabled me to trace a similarity between the two in a geologic point of view, which satified my inquisitiveness. This new aspect, however, afforded me an opportunity for escaping a servile imitation.

In these remarks I do not presume to entertain the notion that I am enunciating what would have remained unknown, but simply what is not sufficiently understood in practice. I find that Payen, Scoffern, and other eminent men have preceded me in the same direction, and that they suggested what appeared to me to approach success so near by a new path at to invite the attention of those who suffer an immense loss.[*]

The authority to whom I have alluded tells us that "The juice is rapidly fermented after extraction, unless the vegetable remains that always float in it have been removed; from which it is inferred that the granular substance or matter, performs an essential part in the fermentation of the juice. The juice contains an albuminous matter, to which also the alteration is due. The abstraction of these globules and other organic and albuminoid matters, entails a delay of days in the fermentation, and the juice so treated remains without alteration, are facts which need but to be enunciated to cause their importance to be understood. They might doubtless lead to very satisfactory results, were they to form the base of a new process applied to our sugar industry. In the ordinary practice of our mills, as arranged at the present day, this process would be attended with three advantages. It would,—

1st, Preclude immediate fermentation of the juice, and preserve it nearly unaltered, at least one day.

2nd, It would reduce the proportion of uncrystalisable sugar.

3rd, We would have a limpid liquid, which, if concentrated, preserves its original transparent purity.

It may be added that the globular and albuminous substances, to which the acidity of the juice is chiefly due, are among the principal causes of the glucose (treacle) transformation of the sugar.

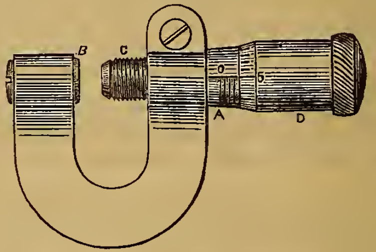
On the other hand, it will be remembered that the means at our command for effecting the defecation and freeing the juice from the impurities which it brings with it, and those produced during the evaporation are impotent to completely restore the juice to purity. Whatever care may have been used this liquid, when it has arrived at the syrup stage, still contains a very considerable quantity of minute matter, consisting chiefly of albuminoids and granular matter. These particles, owing to their levity, are not easily separated or precipitated by rest; they adhere to the sugar, and give it a dark brown colour. The quantity of corpuscle present readily accounts for the difficulty in producing a bright sugar." I could not deny myself the pleasure of quoting so freely one of our highest chemical authorities in confirmation on this subject, one who so keenly suspected the character and function of those infinitesimal globules in the juice, and as clearly demonstrated, by anticipation, the beneficial consequences of their isolation, together with that of the albumen.

We hear of an attempt about to be made to cure meat in Australia with sugar, the cured meat to be imported here. Of course, if approached in a proper manner, such an enterprise may be very profitable.

## POCKET SHEET METAL GAUGE.

The difficulty of accurately measuring the thickness of sheet metals is well known to all persons who have occasion to use or deal in them. The edges of metals being often imperfect, ordinary gauges are prevented from going on readily. It also usually happens that the extreme edges are thinner than the rest of the sheet and cannot therefore be relied upon to give the thickness correctly. In selecting sheets for many purposes, it is desirable to have a gauge to indicate the exact thickness in parts of an inch, and to accomplish this result the gauge shown in the cut has been devised, which will show the thickness of a piece of metal up to three-tenths of an inch in thousandths of an inch, and at some distance from the edge of the sheet.

The piece in the form of the letter U has a projecting hub, A, on one end. Through the two ends are tapped holes, in one of which is the adjusting screw, B, and in the other the gauge screw, C. Attached to the screw, C, is a thimble, D, which fits over the exterior of the hub, A. The end of this thimble is beveled, and the beveled edge graduated into twenty-five parts and figured, 0, 5, 10, 15, 20. A line of graduations 40 to the inch is also made upon the outside of the hub, A, the line of these divisions running parallel with the centre of the screw, C, while the graduations on the thimble are circular. The pitch of the screw, C, being 40 to the inch, one revolution of the thimble opens the gauge $\frac{1}{40}$ or $\frac{25}{1000}$ of an inch. The divisions on the thimble are then read off for any additional part of a revolution of the thimble, and the number of such divisions are added to the turn or turns already made by the thimble, allowing $\frac{25}{1000}$ for each graduation on the hub, A. For example, suppose the thimble to have made four revolutions and one-fifth. It will then be noticed that the beveled edge has passed four of the graduations on the hub, A, and opposite the line of graduation will be found on the thimble the line marked 5. Add this number to the amount of the four gradations, which is $\frac{100}{1000}$, and it equals $\frac{105}{1000}$, which is the measurement shown by the gauge.



The gauge illustrated above, which is the full size of the implement, will measure the thickness of sheet metal or other material, by thousandths of an inch up to three-tenths of an inch at any point within half an inch from the edge, and will also answer to measure the diameter of wire. Means of adjustment are provided in case of wear by continued use, by means of the screw B tapped in the opposite leg of the guage.

## DOUBLE DEFLECTING ARMOUR PLATES.

A very interesting paper was read by Mr. J. M. Hyde on the 15th ult. before the Royal United Service Institution, describing his system of protecting war vessels by means of deflecting armour plates. This arrangement consists in sponsoning or flambing out the sides of the vessel from a short distance below the water line to any desired height above water, after which the sides are sloped inboard until a sufficient height between decks is obtained. The sides, together with the bow and stem, which are rounded, thus present a sharp angle to the enemy's guns, somewhat similar in section to that shown in Mr. Elder's circular ship, and which was illustrated in Plates 333 and 335 of The Artizan. The vessel is then covered with armour plate of moderate thickness, say from 3 to 4 inches, upon which is bolted timber to the thickness of about 12 inches, the grain of the wood running endways or down the angular side. Thus protected, Mr. Hyde contended that a ship would be perfectly invulnerable to the heaviest guns at present manufactured, and gave the results of a very ingenious set of experiments which he had carried out, to prove his position. As it would be far too expensive for him to test his system in the usual manner at Shoeburyness, he adopted the simple method of reducing everything to a scale of an inch to the foot, and made a model Armstrong 600-pounder with a bore of 1 instead of 12 inches, which he used for firing at different forms and thicknesses of targets, but all similarly reduced to the same scale. In order to show that the results thus obtained were fair representations of the Shoeburyness trials, Mr. Hyde exhibited various plates which had been fired at when in the usual upright position, and in each of these cases the amount of damage done was an exact miniature of the full sized trials, and which was fully acknowledged by well known authorities then present. Similar experiments against plates covered with wood and placed at an angle of about 30° with the horizon, according to Mr. Hyde's system, proved that the shot would not quite penetrate the wood, the shot being deflected in a direction parallel to the fibres of the wood, and leaving the iron plate untouched. From this it would appear that Mr. Hyde has shown enough to make it desirable that full sized experiments should be made in order that the accuracy of his views may be fully tested. The plan of making experiments to scale is we think also well worthy the serious consideration of government, as the expenditure incurred by the Shoeburyness trials is so great that the public would be exceedingly gratified if they were in future reduced to one-twelfth their present dimensions.

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[*] At present we lose about two-thirds of the sugar in the juice, and the total value of the lost sugar, according to Dr. Scoffern, is about £60,000,000 annually; or some four millions of tons of sugar.

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## ON MARINE PROPULSION.

By Francis Campin, C.E.

Throughout the range of engineering science there have been but few subjects which have engaged so much attention as that which refers to marine propulsion. Even in the mercantile marine, it is not one nation alone that is interested in ascertaining the most economical modes of applying motive power to the propulsion of vessels, but the whole world, and looking at the question in a broader light, we find our topic of paramount importance in the interests of social and political economy, and also in the interests of humanity.

The country of which the merchandise is carried at the maximum speed, with a minimum consumption of fuel, will evidently realise the the greatest profit on a given amount of capital, for there is not only the saving of fuel to be taken into consideration, but also the fact that the freight being a shorter time on the passage, the profits are sooner realised.

Politically, we have to seek for such a system, as without being in itself extravagant in first cost, shall really yield reliable results and not terminate in successive failures which, although they may by some be thought useful, as giving experience (be it observed, at a great expense to the country in which they occur), would yet form but a contemptible fleet for either offensive or defensive purposes.

Under these various circumstances it indeed appears somewhat strange, that out of all the systems of marine propulsion which have been from time to time brought forward, it has not yet been decided to which classes of work the different methods are severally most applicable. It is easy to understand that paddle-wheels, with their concomitant gear, are unsuited to purposes of war where the vessels may come into action; hence, naturally, the screw propeller is resorted to, as a rule, but there is a third method which appears to us to require a closer scrutiny than any to which it has yet been submitted—we refer to hydraulic propulsion.

Although it is many years since hydraulic propulsion was first brought forward into public notice, and much has been said as to the economy which must result from its adoption, yet do we not only find that the system does not obtain much favour, but also that it is exceedingly difficult to procure anything approaching to satisfactory reports of the trials of vessels fitted with the apparatus to which we refer.

The *Nautilus* was stated to make as good speed as the best Chelsea steamboat, with which a fair comparison might be made, but one question yet requires to be answered—What is the relative consumption of fuel? Again, in most cases the machinery of the hydraulic propeller occupies much more room than that required for screw or paddle engines, and this, for mercantile vessels, would be fatal to the adoption of the first plan.

We shall now proceed briefly to review some of the plans which have been made public relating to hydraulic propulsion, as some of them appear to possess certain merits which, were they applied to purposes for which they are peculiarly adapted, would probably ensure some success.

Ruthven's system first demands our attention, and it appears, even at the most cursory glance, to exhibit defects of a very grave character, the water issuing from the nozzles and intended, by its re-action, to propel the vessel, has as an abutment upon which to act, a light and very mobile fluid—the air—and as the resistance must be equal to the pressure before motion by re-action is secured, there must be much force wasted in creating aërial waves to afford sufficient resistance to the jets of water to enable them, by re-action, to propel the vessel to which they are attached. Leaving this part of our question for a short period, as regards the peculiar method of propulsion of which we are treating, we may show that it is necessary where motion is produced by re-action that there should be some medium or point of abutment exhibiting a resistance equivalent to the force requisite to produce the velocity at which the vessel is being propelled. Considering the case of a paddle-wheel steamer, we observe that almost invariably, if not quite, there is a more or less considerable wave thrown up behind the floats of the wheel, and these waves are evidently required to afford the requisite pressure on the centres of the floats. This pressure must evidently be equal to that which would propel a jet of water at the centre of the floats with a velocity equal to that at which the vessel is progressing, it is also clear that power must be lost in raising these waves, as a certain weight of water is actually lifted by the engines to be ultimately dispersed by gradual subsidence in the wake of the vessel.

This argument will also hold good when applied to any kind of matter, whether solid, fluid, or gaseous; hence its bearing upon the action of Ruthven's propellers, for inasmuch as air has far less weight than water, so will a greater amount of undulatory disturbance be required in air than in water, in order that the resisting medium may offer a sufficiently solid abutment for the propelling jets to act upon.

From these remarks it may be deduced that it is advantageous in all reacting propellers to have them placed in as dense a medium as may be available and at a depth proportionate to the speed at which it is designed to propel the vessel.

We shall not in relation to this subject compare the screw propeller with the paddle, as by so doing our remarks would be extended over more space than is at present convenient, on account of the many points in which the action of the screw differs in principle from that of the paddlewheel; but it may be remarked in passing, that the wave thrown up by the immersed screw is inconsiderable compared to that in the wake of a paddlewheel.

Unlike Ruthven's, the "Hirudine" propeller acted under the surface of the water, water being drawn in at the stem and ejected at the stern of the vessel, but the means used to attain this end were far too complex and uncertain to allow of the invention becoming practically successful, the mode of its operation was as follows:—in the lower part of the vessel was formed a rectangular channel extending from stem to stern, and within this channel was placed throughout nearly its entire length a horizontal diaphragm which, however, was not attached to the sides of the channel, but supported and actuated by a number of connecting rods working from cranks on a longitudinal crank-shaft placed directly over the channel. The cranks were so arranged as to produce a wave-like, hirudine, or leech motion in the diaphragm, thus inducing a current to flow from one end of the channel to the other, which by its reaction would propel the vessel.

Next we may refer to Gumpel's Hydraulic Propeller. In this also a current is induced through a channel placed under or near the bottom of the vessel to be propelled, but the motion of this current is created and regulated by the action of ordinary pumps, which certainly possess the advantage of being certain in their action, although they occupy considerable space. The patent for this invention was allowed to lapse, but from the results of experiments tried with models a few years back we are disposed to think that the subject is worthy of the serious consideration of engineers and shipbuilders.

This method has been revived, but the ordinary pumps are replaced by centrifugal ones, and here is introduced an element which we consider is accompanied by uncertainty, and more especially when working at low speeds. The centrifugal pump possesses the advantage of being more compact, but, again, requires in many instances a greater consumption of power than the piston pump.

One of the most recent designs in which the submerged hydraulic propeller is introduced is that of Mr. John Elder's for circular vessels of war, in which it is necessary to have such means of propulsion as shall satisfy the requirements of manœuvring, by proceeding in any direction, or causing the vessel to revolve upon its centre. It is not in this paper pertinent to discuss the merits of the class of vessels alluded to, but we may observe that in our opinion the propeller selected is most admirably adapted to attain the ends required.

In concluding these remarks, we do not wish to be misunderstood as to our opinions on the subject of hydraulic propulsion, but particularly should be impressed the importance of having complete and reliable reports of the various trials of new or improved propellers, and more especially of such as have been so often tried and abandoned. We believe in yet obtaining good and economical hydraulic propellers, provided they be submerged; but otherwise, for the reasons adduced above, we have but very little faith in them.

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A System of metallic ceilings, which consists in the application to the joisting of very thin stamped metal in ornamental embossed panels, has lately been invented in the United States. These stamped panels are fitted for every kind of decoration in colour, and if inserted as plain surfaces may be used as the ground for every description of cartoon painting, combining with lightness and durability artistic and ornamental effect.

## CHEMICAL SOCIETY.

After the usual formal business, the President announced that Dr. Wallace, of Glasgow, who had promised a lecture "On the Chemistry of Sugar Refining," had been prevented by illness from attending, but that he had forwarded his diagrams and tables, together with the MS. of his lecture, and that the latter would now be read by the secretary.

Mr. Vernon Harcourt accordingly proceeded to read the discourse, of which the following is an abstract:—

After a few introductory remarks upon the complexity of the science of chemistry, upon the importance of the technological branches of it to many Fellows of the Society, and upon the encouragement afforded to the study of those branches by the Society, the author draws attention to the statistics of the sugar trade in this country. From the Board of Trade returns for 1868, it appears that 594,656 tons of sugar of all sorts were imported in that year. The duty on this quantity amounted to nearly five and a half millions, and the total money value, including duty, to £21,000,000. At least 400,000 tons were refined in this country. Foreign countries, particularly France, offer very formidable opposition to the English refiners, no less than 34,039 tons in 1868, and 42,047 tons in 1867, of refined sugar having been imported. The author has shown, in a previous discourse, the unfair terms on which our refiners have to deal with foreign countries. He attributes the present stagnation of the sugar refining trade in London mainly to this unfair competition, but also to the extraordinary development of the industry within the last few years in Greenock and Glasgow. In 1857 the quantity of sugar refined in the Clyde was 38,336 tons, while in 1867 the quantity had risen to 178,013 tons. Last year it amounted to only 171,643 tons, but even this quantity is two-fifths of the whole amount of sugar refined in the United Kingdom. The author believes that the London refiners have been somewhat slow in adopting the most recent improvements introduced in the provincial refineries, and they have been unwilling to give up the making of loaf sugar, which is not now profitable. They work, moreover, under considerable disadvantages in various respects. The refining process here described is that adopted at Greenock for crushed or soft sugar. Its chief peculiarity is that no syrup is produced; all the sugar leaves the refinery in the solid form, and the loss of all kinds only amounts to about 5 per cent.

SUGAR REFINING.—A proper selection of the raw sugar is a very important point in the refining process. In the Greenock system the raw sugar employed must not contain more than 3 or 4 per cent of uncrystallisable sugar; but where syrup is produced this is of less importance, and concrete and low sugars may be used. Mixtures are often judicious, but on the Greenock system a large proportion of beet sugar is avoided. Several points must be considered in purchasing raw sugar for refining—the proportions of cane and fruit sugar, the amount of extractive, as determining the quantity of animal charcoal required and its deterioration in the process, and the amount of insoluble matter, which, when excessive, is troublesome to wash, must all be taken into account.

The author next gives a table of the composition of twenty samples of raw sugar of different kinds, but remarks that they must not be taken as typical of the various kinds indicated, as they vary extremely in composition.

The French mode of determining the value of a sample of sugar is, upon the whole, a very fair and accurate one. Each percentage of fruit sugar is assumed to prevent the crystallisation of 1 per cent., and each percentage of soluble salts of 5 per cent of cane sugar; thus a sample of Paraiba sugar contained 84·9 of cane sugar, 6 of fruit sugar, and 1·7 of soluble salts; this sample would accordingly yield 70·4 per cent of cane sugar.

FIRST OPERATION—SOLUTION.—This, which is technically known as "blowing up," from the fact that open steam was formerly used in it, is effected on the highest floor but one of the building. The blow-ups are cast-iron pans, 4 or 5 feet high and 6 to 10 feet in diameter. The steam is admitted by a heating worm below a false bottom; above and below this false bottom revolving arms keep the liquor in constant motion. Water is introduced into the blow-up, the steam turned on, and the sugar thrown in as quickly as possible from the floor above. In half an hour the filling should be completed, when the liquor should have a specific gravity of about 1·225 (28° Baumè) and a temperature of 180° F. It consists of about two parts of raw sugar to one of water, and a pan of 10 feet diameter will dissolve about 7 or 8 tons of raw sugar. A small amount of flocculent and insoluble matter is removed as scum during the operation. This is the simple process pursued in most of the Clyde refineries; but in others various methods of treatment are adopted to facilitate the purification. Milk of lime is sometimes added to neutralise the small trace of acidity in the raw sugar, and the author thinks this useful, provided that an excess is avoided. The use of blood or albumen was formerly common, but as they render the syrups impure, they are now generally dispensed with. Other reagents have also been used, such as sulphate or phosphate of aluminium or lime, or soluble tricalcic phosphate and lime, but there is great danger of the workmen adding too much of one or another of them, and their use does not appear to be necessary. The dust of animal charcoal has a good effect when quite new, but it cannot be used more than once.

The next operation consists in passing the solution through twilled cotton filter bags in coarse canvas sheaths. These bags are fastened, to the number of 200 or so, to the bottom of a shallow tank, into which the liquor from the blow-up pan is passed. The sides are kept hot by steam.

DECOLOURISING THE SYRUP.—Animal charcoal has been found by practical experiments to be the most suitable for sugar refining. Many things have been tried, some of them much more energetic than it as decolourising agents, but none possess its peculiar combination of valuable qualities. An artificial mixture of clay and some form of carbon has been said to rival animal charcoal, but the author has heard nothing of it lately. Seaweed charcoal approaches most nearly to that of bones, but wants some necessary characters. Sulphurous acid has been tried repeatedly, but it never removes more than three-fourths of the colouring matter, and its liability to change into suphuric acid renders its use dangerous; for though sulphurous acid does not alter cane sugar, the latter acid does, and even if this is neutralised by lime, the resulting sulphate of lime is injurious to the charcoal, which must subsequently be used. The author has made no experiments on the bleaching action of ozone, but fears that its oxidising action on the sugar would prove troublesome. The carbonatation process used on the Continent is excellent for the juice of the beet, but would not be advantageous in the refining of raw cane sugar. It might be found useful in certain cases, as for instance in purifying the washings of animal charcoal. The author considers that it is an excellent arrangement to have a smaller refinery connected with the larger one for the separate treatment of impure products. The use of alcohol with a minute portion of hydrochloric or acetic acid, to remove earthy salts before filtration, is next discussed; it has been tried on the large scale in Belgium, but discontinued. Theoretically, it is most advantageous, but its expense would be fatal to its use here, except, perhaps, with duty-free spirit. A moderate-sized sugar house would require about 10,000 gallons of almost absolute alcohol, and this must be re-distilled every day. The process has long been used most successfully for testing raw sugars.

FILTRATION THROUGH CHARCOAL.—The clear liquor is now run into iron tanks filled with animal charcoal, allowed to "settle" for several hours, and drawn off colourless below. At the same time more of the dark liquor is run in at the top, so as to keep the cistern full. When the sugar solution begins to come away yellow, the sugar solution is replaced by the syrup from a previous refine; the whole of the sugar is then washed out with hot water, and the charcoal, after draining, is taken to the kiln to be re-burned. The author gives many interesting details as to the size of the cisterns, the size, or "grist" of the charcoal, &c., which our limits compel us to omit. He refers, for a full discussion of the qualities of animal charcoal, to a lecture delivered in Glasgow during last year. In the present discourse he confines himself to the consideration of certain points.

Three analyses of new animal charcoal are first given, the samples containing respectively 9·71, 7·64, and 10·37 of nitrogenous charcoal, in the dry substance. As sold it generally contains about 10 per cent of water. The so-called carbon of animal charcoal contains a notable proportion of nitrogen, and a little hydrogen. The nitrogen is generally about 1-10th of the total carbonaceous matter, but is sometimes considerably more. Old charcoal contains less nitrogen, and the proportion constantly diminishes. The nitrogen appears to be an essential constituent of animal charcoal. Red-hot animal charcoal, quenched with water, evolves ammonia, and the practice ought, therefore, to be avoided. New charcoal always contains traces of ammonia, as well as of sulphides of ammonium and calcium. In a particular case ·11 per cent of ammonia was found; and in another, a sample of charcoal evolved ·08 per cent of hydric sulphide when treated with an acid. Both new and old charcoal retains appreciable quantities of gases, which escape when the tanks are filled with liquor, and sometimes explode when a light is brought to the top of the cistern.

Old charcoal should always contain more carbon than new, on account of the carbonisation of the impurities separated from the sugar. If the carbon does not increase with the age of the charcoal, it shows either that air has been admitted during the re-burning or that the re-burning has been effected at too high a temperature. The increase of carbon in the charcoal is an evil, and should be diminished as far as possible by thorough washing before it is re-burnt. The extensive washing has another advantage, for it tends to remove the mineral salts, particularly calcic sulphate, which has been taken up from the sugar. As long as the sugar liquor is strong, calcic sulphate is absorbed and retained by animal charcoal; but when the washings begin, the salt comes away in solution.

Another cause of the deterioration of charcoal is the constant shrinking of its volume, and its consequent diminution in porosity. A ton of new charcoal usually occupies about 50 cubic feet, but this diminishes to 40, and even in one case to 28 cubic feet. This appears to be due to a partial fusion of the calcic phosphate, and is not accompanied by any great alteration of specific gravity. All these considerations point to the necessity of renewing the charcoal very frequently. With regard to the quantity of charcoal required, much depends on the nature of the sugar. For a ton of sugar, 25 cwts. of good charcoal is amply sufficient; and for fine sugar an equal weight is enough. The less used the better; and it is a mistake to suppose that a large quantity of bad or exhausted charcoal will serve the same purpose as a smaller amount of good. The work will not be so well done, and the waste of sugar will be greater, As illustrations of the composition of old charcoal, the author gives his analyses of nine samples, which differ very remarkably in composition. The percentage of nitrogenous carbon varies from 2·56 to 19·64.

The calcic carbonate in charcoal is useful in neutralising the minute quantity of acid present in all sugars and also the acids always formed during the washing of the charcoal. When very soft water is used, the quantity of calcic carbonate diminishes or even disappears. On the other hand, with very hard waters, or when lime is added in the process, as in the beet factories of the Continent, it often increases to an inconvenient extent. This is the best remedied by Mr. Beans's process, which consists in impregnating the burnt charcoal with perfectly dry hydrochloric gas, exposing it to the air until the excess escapes, washing thoroughly with water and burning. Beanes's process and others of a similar nature may be applied with advantage to new charcoal, to bring it at once into efficient working condition.

The oxidising power of the charcoal is attended with a grave inconvenience in sugar refining. When the char cisterns are to be washed off, hot water is introduced, while the heavier syrup descends, but the liquids commingle to some extent, and a weak solution of sugar is formed, which is exceedingly liable to undergo the lactic fermentation. The ferment appears to be generated by the action of the dissolved oxygen of the water under the influence of the charcoal upon the vegetable albumen removed by the charcoal from the sugar. It is a common, but very mistaken custom to use the char washings in dissolving fresh sugar.

With respect to the temperature required in the refining process, the liquor in the blow-up pans should be run off at 180° F.; the char cisterns should be at 155° F., and never below 150°; and the water used for washing should be absolutely boiling. The minimum quantity of water required for refining 100 tons of sugar is about 215 tons, or nearly 50,000 gallons.

Revivifying of the Charcoal.—The re-burning of the charcoal is effected in kilns, which consist of upright cast-iron pipes arranged in rows. The wet charcoal is introduced at the top, and sinks down as from time to time the portions which are sufficiently burned are drawn off at the bottom. The flame plays directly upon the pipes, and those which are nearest to it receive the most heat, and their contents must be exposed to it for a proportionately less time—five hours being sufficient for the nearest row, whereas ten hours may be required for the farthest. It is a great mistake not to dry the charcoal, either partially or completely, before introducing it into the kilns, as the wet mass hinders the escape of gases from the lower portions, and much heat is wasted in evaporation.

Evaporation of the Liquor.—This is effected, as is well known, in the vacuum pans. The improvements introduced of late years into the vacuum pans consist in increasing the extent of heating surface and the quantity of water injected into the condenser, and in enlarging the neck of the pan to 18 inches, or even more. A good sized pan is 10 or 12 feet in diameter, and holds about 20 tons of sugar and syrup. The boiling down occupies two or three hours, the vacuum averages about 28 inches, and the temperature is usually about 120° F. at the beginning, and about 130° F. at the end of the process. The solution is introduced a little at a time, and the first portion is boiled until a "grain," consisting of almost microscopic crystals of sugar, forms, and these increase in size as the boiling proceeds, until at the finish they are as large as may be desired. When large, distinct crystals are required, the liquid is boiled more slowly and at a higher temperature, and when the pan is full, only one-half of the contents is drawn off. This is repeated several times, the crystals becoming larger every time. The author points out that it is not necessary to increase the temperature, but only to diminish the rapidity of the boiling, in order to obtain fine crystals. The high temperature usually employed for the production of large crystals only serves to increase the quantity of uncrystallisable sugar formed, and to darken the colour of the syrup.

In boiling down the syrup obtained from the drainage of the first crop of crystals, less care is required, a small grain being preferred as carrying more syrup. Three qualities of sugar are usually prepared by this process, viz., whites, mediums, and yellows. For the yellows, the syrup is evaporated as a "jelly," that is, the formation of grain is entirely avoided, and the jelly is left for several days to crystallize. The crystals of all three kinds are separated from the syrup by a centrifugal machine, the periphery of which travels something like 100 miles an hour. From three to twenty minutes are occupied in the drainage, according to the quality of the sugar. The whitest crystals are sometimes washed with a little cold water.

## LONDON ASSOCIATION OF FOREMEN ENGINEERS.

On Saturday the 13th of February, the sixteenth anniversary of the above Association was celebrated by a dinner at the City Terminus Hotel, Cannon-street. Joshua Field Esq., C.E., occupied the chair, and R. Moreland, Esq., C.E., the vice chair. The members and guests numbered nearly 200, and amongst the company present we observed General Lefroy, R.A., F.R.S., E. J. Reed, Esq., C.B., Joseph Whitworth, Esq., L.L.D., F.R.S. W. Todd, Esq., C.E., Robert Mallet, Esq., C.E., F.R.S., Frank Ives Scudamore, Esq., of the Post office, Henry J. Slack, Esq., F.G.S., Captain Rintoul, Edward R. Allfrey, Esq., C.E., Edward Humphrys, Esq., C.E., John Penn, jun., Esq., Charles Seidler, Esq., John R. Ravenhill, Esq., C.E., W. Smith, Esq., C.E., James Robertson, Esq., V. Pendred, Esq., Passmore Edwards, Esq., Dr. Fennell, J. Walker, Esq., Mr. Newton, of the Mint, &c.

After the usual loyal toasts the Chairman proposed that of the "Army, Navy, Militia, and Volunteers," which was responded to by General Lefroy, and Mr. E. J. Reed, C.B., the Chief Constructor of the Navy, Captain Moucrieff, who was also to have responded, being absent from illness. The report of the secretary, Mr. D. Walker, was then read, after which "Prosperity to the Association" was proposed by the Chairman, who coupled with the toast the name of its indefatigable president, Mr. Joseph Newton. Mr. Newton, in responding, very happily referred to the relations between the foremen engineers and their employers, and pointed out the good feeling and perfect understanding which existed between them. He also referred to the satisfactory condition of the Association, which was due in some respects to the employers as well as to the members themselves.

The Association was founded in 1852 by a few zealous and intelligent foremen, who felt that the class to which they belonged occupied, intellectually and socially an isolated and unsatisfactory position. They, therefore, at once proceeded to constitute themselves a society. They struggled on for some years, and having weathered the storm, the London Association of Foremen Engineers is now in vigorous health. Each year witnesses a steady accession to its list of honorary and ordinary members. The first-named class comprises some of the most eminent employers of engineering labour in the metropolis, and many gentlemen distinguished for their scientific acquirements and high social position. The second are drawn from the ranks of foremen and draughtsmen connected with the various branches of the engineering trade, and who are only eligible after having occupied principal posts for the space of two consecutive years.

The operations of the Association are conducted on two distinct bases—the one scientific and practical, and the other benevolent. It has its monthly meetings for the discussion of practical subjects, its library of mechanical works, and other agencies of a like nature for the dissemination of knowledge useful to associates. Upon its second base—that of benevolence—four distinct funds have been established. The first of these has reference to the temporary assistance of unemployed members, and is maintained exclusively by the annual subscriptions of ordinary associates. The second, for the payment of a certain sum on the death of a member, is maintained from the same source. The third fund is that for partially maintaining old, decayed, and worn-out foremen, who have been members, and who are unable wholly to sustain themselves. This is known as the superannuation fund, and it is almost exclusively the creation of the employers and other honorary members of the Association.

Let us now turn to its present position, as represented in the following extracts from the sixteenth annual report, which was read by the secretary upon the present occasion. That document records a continuance of the steady progress of former years; while the established features of the Association have worked steadily and well, new ground has been opened and fresh enterprise entered upon. Ten ordinary and seven honorary members have been added during the year, and two deaths have occurred, the effective number being 104 ordinary and 67 honorary members. The income of the past year was £221 10s. 6d., whilst the expenditure was £261 14s. 9d. These figures show the expenditure to have been £40 4s. 3d. in excess of the income, the effect of the severe commercial panic, which necessitated payments to a number of unemployed members. The present value of ordinary funds invested in stock Three per Cent. Consols is £364 4s. 2d.; there is in the savings' bank the sum of £65, and in the treasurer's hands £4 18s. 9d., making a total of £134 2s. 11d. A widow and orphans' fund was established in the early part of the past year, which has not progressed quite so satisfactorily as could have been wished. To the superannuation fund there was subscribed by the various gentlemen present a total of £95 14s., which, with subscriptions previously acknowledged, gives a grand total of £1,044, 16s. 2d. We are glad to learn that this fund, with the accumulating interest, remains intact, no application having yet been made for the benefit it provides, although when applicants do come forward, the amount will go but a short way in providing for them, as the interest—the only part that will be appropriated—would suffice for but two at the rate laid down. The interest in the proceedings of the monthly meetings—of which abstracts appear in our columns—continues to increase, and they are found to improve in usefulness as the papers become more practical and less speculative; in fact, in every department of this Association there are evident tokens of advancement and steady progress, which must, by improving the intellectual and social condition of the foremen engineers, act beneficially upon the interests of the employers of engineering skilled labour.

## INSTITUTION OF MECHANICAL ENGINEERS.

### ON AN IMPROVED CUPOLA FOR IRON FOUNDRIES.

By. Mr. Jacob Eichhorn.

In Cupola furnaces the blast enters generally either through tuyeres, or through horizontal or vertical slits at the sides of the cupola; but a disadvantage attends these arrangements, inasmuch as the blast being too cold at the beginning to combine at once with the carbon of the fuel, must first be diffused through the fuel before it can burn, and the greatest heat is therefore produced at a point situated above the tuyeres. The height of this point various with the respective quantities of fuel and of blast that are introduced; and when sufficient fuel is supplied, the point of greatest heat will be situated at the level where all the oxygen in the blast has become carbonic oxide. It is found in practice that the range of level of this point extends over several feet, according to the quantity of fuel used, the height being generally about 3ft. above the level of the tuyeres; but in the cases mostly met with in foundries there is not a sufficient supply of fuel close to the tuyeres or openings where the blast enters, and in these cases therefore the blast does not meet with sufficient fuel for complete combustion until it arrives at the upper layers of the fuel, and it consequently passes the hot metal and causes it to be burnt. The waste upon the metal put into the cupola amounts to from 5 to 10 per cent. generally in these furnaces; and the rapid burning away and destruction of the lining extends over a height of 5 to 6ft. from the hearth. Another disadvantage, resulting from the necessarily confined space occupied by the tuyeres or blast openings, is that the blast, being thereby concentrated, acts upon the carbon contained in the iron, and consequently deprives the iron more or less of its fusibility.

To remove these advantages of the ordinary construction of cupolas, a plan has been devised and carried out successfully by Mr. Henry Krigar of Hanover, which forms the subject of the present paper, and aims at the accomplishment of the following objects:—to concentrate the heat in the lower part of the cupola, where there are facilities for easily repairing the

FIG. 1.

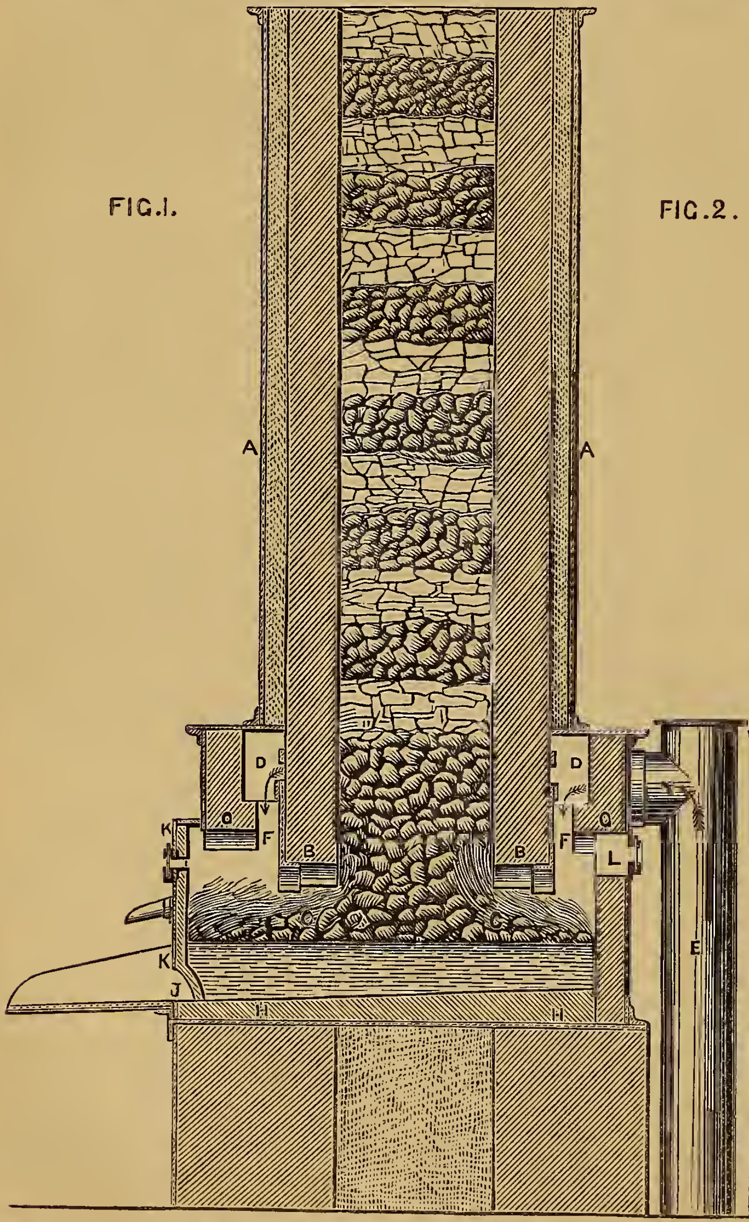
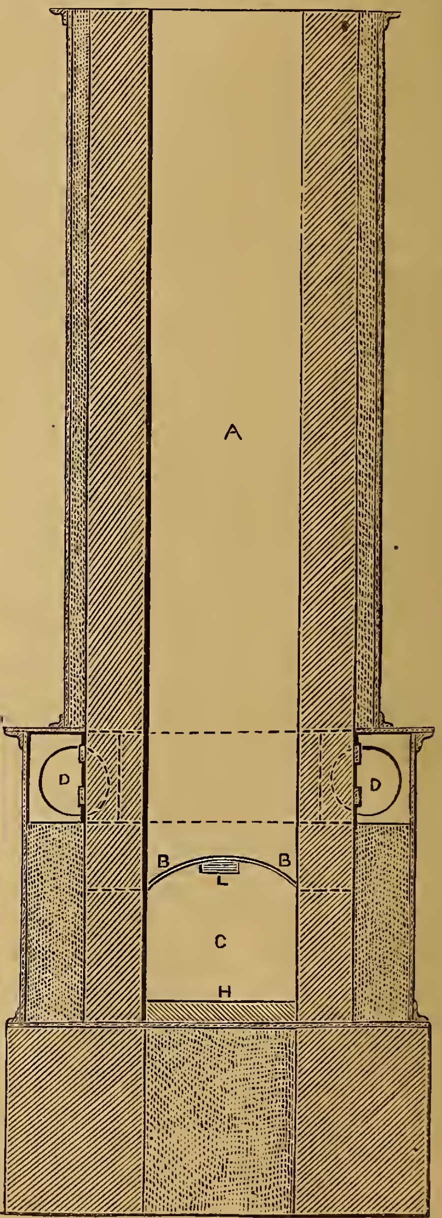
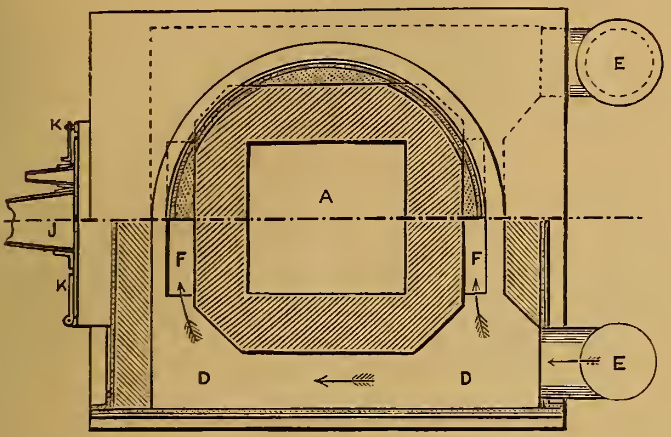


FIG. 2.



furnace lining, and to render the action of the cupola uniform throughout the operation of melting; to give the hearth such a size that the column of fuel between the layer of melted metal and the level where the blast enters the interior of the furnace may vary but little in height, so as to limit the range of the destructive action upon the furnace lining; and to ensure the blast being taken up by the carbon of the fuel from the moment of its entering the furnace, and thereby prevent it from injuring the heated metal by oxidising it.

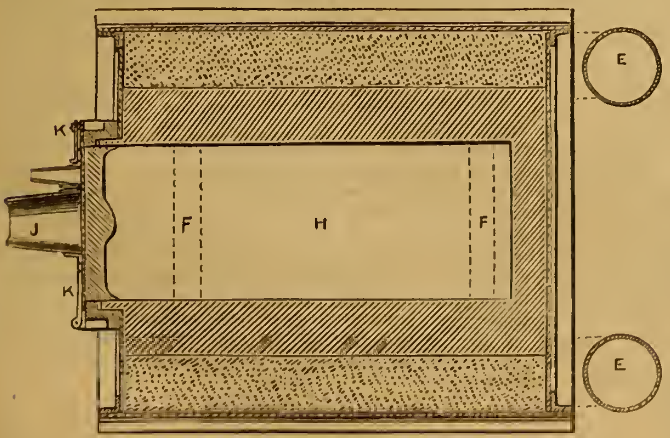
Fig. 3.



The construction of this cupola is shown in Figs. 1 to 4, Fig. 1 a vertical section from front to back, Fig. 2 a vertical section from side to side, and Figs. 3 and 4 are sectional plans at different levels.

The vertical shaft A A of the cupola is made rectangular in form, either square or oblong, as shown in the plan, Fig. 3, and parallel or with very little taper in height, so as to avoid any prominent part upon which the flame could strike, and which would be exposed to rapid destruction. A backing of sand is used behind the brickwork to concentrate the heat in the cupola. The shaft A is supported at front and back by arches B B over the lower chamber C C; and at the sides of this chamber is also a backing of sand, as shown in Fig. 2, to keep the heat in. Over this backing and round the bottom of the shaft A runs the air passage D D, into which the blast is delivered from the two air mains E E; and the blast entering through this passage cools the brickwork of the cupola, and becomes heated itself; it then passes down into the melting chamber C C through the two long slots F F in the roof, one at the front and the other at the back, extending the whole breadth of the hearth, as shown in the plans, Figs. 3 and 4. These slots are constructed by leaving a space of 4½in. width between the outer arches O O, Fig. 1, and the inner arches B B that carry the shaft A; the length of the hearth H from front to back is consequently made greater than the breadth. The front of the cupola is closed by an iron door K on hinges, extending the whole breadth of the hearth; and a smaller door L is placed at the back, to facilitate the drawing of the cupola by inserting a rake at the back; by this means the drawing of the cupola can be accomplished regularly within 3 or 4 minutes.

Fig. 4.



For starting the cupola, about 1 to 1½ cwt. of coke is placed on shavings or some burning coke upon the hearth, and more is added by degrees from the front door, until all the coke intended for the first filling is put in. The door K is then closed, being first wetted on the inside; and the tapping hole J is formed as usual by placing clay round a wetted stick. The whole height of the door is then plastered on the inside with a mixture of clay and sand, the door being set forwards about 5 in. in front of the breast of the furnace, to allow space enough at top for the furnace man to get his arm in for lining the door; and the space at top is afterwards closed with bricks. This mode of closing is adopted for cupolas working with a pressure of blast of from 4 to 7 in. of water; but where the blast is stronger a wall is first built up inside the melting chamber C and wetted; and the door being shut and secured with wedges, the space between the door and the wall of coke is then filled with foundry sand rammed in.

The amount of filling that is put in for starting the cupola varies with the size of the cupola and the quantity of melted metal that the hearth is intended to contain at once; but the amount is always much less than is usually employed in other cupolas. One of the new cupolas capable of melting 3 tons of iron per hour requires a filling of 2¾ cwts. of coke for starting it, or 3¾ cwts. when it is intended to keep the whole of the melted metal in the hearth, to be tapped all at once. Upon this filling a charge of 8 cwts. of iron is added from the top of the cupola shaft, and then about ½ cwt. of coke; and again a charge of 8 cwts. of iron followed by ½ cwt. of coke; and the same in succession until the whole charge is put in, filling up the shaft A to the top, as shown in Fig. 1. After the casting, a certain quantity of the coke is drawn out unconsumed. The average quantity of coke consumed is 1½ cwt. or 168 lbs. per ton of iron melted, when only 3 tons are melted in each charge; and the consumption is 147 lbs. per ton when charges of 6 tons are melted; and 140 lbs. per ton with heavier charges.

The metal melted in this cupola is found to be very fluid; and indeed so fluid that, in the cases where in an ordinary cupola seldom more than one half of cast-iron scrap is used, this cupola bears under the same circumstances the addition of fully three quarters of scrap. At the same time the softness of the metal is retained; or, as it is commonly termed, the metal is clean. If the cupola be allowed to stand without blast for one hour after the filling is completed, and the blast be then turned on, the metal begins to run down to the tapping hole six minutes afterwards: but if the blast be admitted immediately on completion of the filling, without allowing the cupola to stand, the metal may be made to run from the tapping hole within one hour from the time that the cupola was empty before the filling commenced.

This cupola has the advantage of allowing the whole of the metal melted during one hour to be retained in the hearth; this result however is not obtained by increasing the height from the bottom of the hearth to the crown of the arches carrying the shaft, but by increasing the length of the hearth from front to back, as shown in the longitudinal section, Fig. 1. If the height from the bottom of the hearth to the arches is made too great, the metal loses the great fluidity that distinguishes the working of this cupola. The height from the tapping hole J to the charging opening at top of the shaft A is from 13 to 14 ft. As the construction of the cupola causes it to work hotter than ordinary cupolas, it requires a smaller area of shaft than an ordinary cupola for the same blast and yield, the reduction being in the proportion of about 3 to 7; any existing cupola shaft can therefore be altered to this plan, and will still yield more metal than before in the same time.

The quantity of blast required is 30 cubic feet per second, reduced to the pressure of the atmosphere, for each ton of iron melted per hour. The pressure of the blast used may be as low as 4 to 5 in., but a pressure of 8 or 9 in. is generally adopted. Whether this or a still higher pressure is used, no further economy of fuel is obtained, but only a greater quantity of metal is melted down in the same time by the same furnace.

With regard to the wear and tear of the cupola, the lower part of the shaft A is exposed to the greatest destruction, but that is the only portion which suffers more than the lining of an ordinary cupola, and it is easily accessible for repair. The coke falling from the shaft into the melting chamber C C, fig. 1, stands there in a heap, upon which the blast rushes through the two transverse slots F F in the roof; and the heat from the burning fuel being radiated into the air passages D D, the blast becomes prepared for combining rapidly with the carbon of the fuel, before it has an opportunity of coming in contact with the melting metal and wasting it by oxidation; and the action of the blast is finished, as may be judged from the appearance of these cupolas, at a level of only about 14 inches above the crown of the arches B B. This corresponds to the portion of the cupola that requires to be renewed about every three to four months; and a small arched iron bar of 2 to 3 inches width, remaining constantly in its place in each arch B, allows of the arches being readily replaced at any time without the introduction of centering. The shaft A suffers very little wear itself, and after six months' work it can only be said that the bricks are strongly glazed. When the arches B B are replaced every three to four months, the face only requires patching or plastering up once or at most twice a week; and only about half or little more of the repairing material is required that would be necessary in an ordinary cupola. The total cost of wear and tear therefore does not at most exceed that of the ordinary cupolas, while there is less trouble in keeping the improved cupola in repair.

With regard to economy of metal, the results of the working of this cupola are found to be that in melting pig iron, such as Calder No. 1, the loss amounts to 3·4 per cent. on the metal weighed in; and when mixed with three-fourths of railway-chair scrap, the loss only 2.2 per cent.

## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

(*Continued from page* 39).

"No. 41 Explosion, which was of a very disastrous character, as many as ten persons being injured, two of them fatally, was briefly referred to in last month's report, but at that time full details had not been obtained, as the Association's inspector found the boiler so buried in the *débris* that complete examination was impossible. He has, however, since then made another visit to the scene of the catastrophe so that fuller particulars can now be given.

"This explosion occurred at about half-past two o'clock on the afternoon of Friday, October 30th, on the premises of a steam-sawyer who carried on his business in the basement of a two-storied building, the upper part of which was occupied by glass-cutters and turners, to whom he supplied steam power. The building, which was situated in a thickly populated district and hedged in with houses all round, was a little hive of industry, 20 workpeople being engaged in it.

"On the occurrence of the explosion the boiler was driven through a nine-inch wall, and thrown against another boiler in an adjoining building at work with steam up. Had the blow been a little more severe, explosion would have spread from boiler to boiler, and the general havoc been still greater. As it was, the building overhead was brought to the ground, burying the workpeople in the ruins, ten of whom, as already stated, were injured, two of them dying shortly afterwards, while the fireman, who was also among the number injured, was severely scalded, though not fatally so; in addition to which, a neighbouring building was set on fire which added to the disaster.

"The boiler was of the Cornish type, having a single furnace tube running through it from end to end, in which the fire was placed. Its length was 16ft. 9in., and its diameter in the external shell 4ft. 11in., while the furnace tube, which was oval for a length of 6ft. at the front end, measured 2ft. 11⅝in. horizontally, and 2ft. 6½in. vertically, the remainder being circular, and having a diameter of 2ft. The thickness of the plates was three-eighths of an inch in the external shell, and five-sixteenths in the oval furnace, while it was five-sixteenths and three-eighths of an inch in the flue tube. The boiler was fitted with two safety-valves of open lever construction, weighted to a pressure of 65lbs. per square inch; but there were no glass gauges or gauge taps, the height of the water being indicated merely by an ordinary stone float. It should be added that the furnace tube, though of so weak a shape and made of such light plates, was not strengthened either with flanged seams or encircling hoops, so that it was quite unfit to be worked at so high a pressure as that to which the safety valves were loaded, beside which the boiler was an old one, and had been purchased second-hand by its last owner, while one of the witnesses stated at the inquest that he had known it for 25 years, and it transpired in the evidence of the fireman that the boiler had been repaired two or three times during the last six months, and on one occasion but two or three days before the explosion occurred.

"After this description of the boiler, it will not be thought surprising that it should have failed in the internal furnace tube, which collapsed almost from one end to the other. This case of collapse, however, was by no means an ordinary one, and deserves minute description, as much discussion has been founded upon it with regard to the cause of the explosion. It is difficult, however, to make it plain by description alone; but it may be stated that the collapse was a vertical one, the top of the tube being driven downwards and the bottom upwards until they met one another, or nearly so at a few feet from the back end, while the upheaving of the ashpit lifted the firebridge till it was brought into contact with the furnace crown, and thus arrested the progress of the collapse, so that the crown for a length of about 6ft. from the front end retained its shape unaltered. It is important to observe that, contrary to general experience, the force of the collapse was rather upwards than downwards, the lower part of the tube being driven upwards from end to end, while on the top, the part only behind the firebridge was affected, the remainder immediately over the fire, as already stated, being unmoved. The flue tube, in addition to being collapsed, was rent longitudinally on each side of the flattened part, and also at its attachment to the front end plate at the bottom of the ashpit, the rent running through 14 consecutive rivet holes, while the plate was forced upwards to within 8in. of the furnace crown, thus leaving a large opening through which a torrent of steam and hot water rushed out, scalding the workpeople and hurling the firebars on to some of the adjoining buildings, while the boiler was driven backwards from the re-action.

"The cause of the explosion excited a good deal of interest and discussion. Two inquests were held by different coroners, one of whom applied to the Home Secretary for engineering aid, and received the assistance of of a surveyor to the Board of Trade, who has held the position of chief engineer in Her Majesty's navy. The other coroner also availed himself of the assistance of a scientific witness, and this gentleman, after examining the boiler, reported that he considered the upper part of the flue had been red hot, and that the disaster was due to the water supply being allowed to get too low in the boiler. At the other inquest, the surveyor to the Board of Trade attributed the explosion simply to pressure of steam, considering the boiler, on account of its age and the defective construction of the flue tube, to have been unfit for a pressure nearly as high as that at which it was worked. He considered that the pressure should not have exceeded 30lbs., and that the boiler had been working on in danger for some time. At the close of each inquiry, the juries returned a verdict of 'Accidental death,' but in the one last referred to, censured the boiler owner for "employing incompetent persons to work the boiler as he was not qualified himself.' Other engineers have visited the scene of the catastrophe, and favoured me with the result of their investigations, which coincide with the view that the explosion did not result from shortness of water, but from the weakness of the boiler and its utter insufficiency for the pressure at which it was worked. Added to this, an officer of this Association, as already stated, has fully examined the exploded boiler, so that the cause of few explosions has been more fully investigated than the one in question.

"After carefully considering the views of the scientific witness who attributed the explosion to shortness of water, and reading over his report, with a copy of which he has kindly furnished me, I feel constrained to differ from him for the following reasons. When explosions arise from shortness of water, the plates over the fire are the first to be affected, and the scale, should there be any, is cracked off from the surface of the plates. In this case, however, the plates over the fire remain uninjured, while the scale adhered to them as tenciously as ever. The furnace tube, it should be stated, tapered down just behind the firebridge, so that the crown of the furnace was 3in. above the top of the flue tube, and thus would be the part first to be laid bare by shortness of water, and first to suffer by the overheating, whereas it was the flue tube that was injured, and not the furnace tube. Added to this, when collapse arises from shortness of water, if not confined to the upper part of the furnace tube, it is at all events most severely developed there, whereas in this case the lower part of the tube was more severely collapsed than the top. The furnace tube, 6in. oval, was of a very weak shape, while it appears that at the bottom of the ashpit, where one of the rents took place, repairs had been effected but a couple of days before the explosion, and there is little question that the rent at this part was the primary one, in consequence of which the bottom of the weak oval-shaped furnace flue was upheaved and that this started the upward collapse which worked its way along the tube to the back of the boiler, and, destroying the circular shape of the flue, led to the down collapse of the crown, which would have extended throughout the entire length of the boiler had not the firebridge, raised by the upheaving of the ashpit, formed a support for the furnace crown, and thus arrested the collapse. Thus the origin of the collapse was the rent just where the boiler had been recently repaired at the bottom of the ashpit, and the explosion is attributed, not to shortness of water through the neglect of the attendant, but to the malconstruction of the boiler, which rendered it totally unfit for the pressure at which it was worked.

### "ECONOMISER EXPLOSION.

"Another feed water heater or economiser has exploded, which makes the third that has recently failed in this way. This is something quite novel and surprising, as this apparatus had previously been considered as incapable of explosion. Since these economisers prove of so much service, and are so generally adopted, the question of their safety is one of general importance.

"The explosion referred to occurred in France, on Saturday, December 26th, and by it three persons were killed and others injured. The distance from Manchester at which this took place, combined with the pressure of other duties, prevented a personal examination, which would otherwise have been made on account of the importance of the question, but I expect shortly to be in possession of the details, which shall be reported as soon as possible to the members.

"In the meantime, the suggestions given in the Report for October last, when referring to the recent economiser explosion, may be repeated, viz., that the members should adopt the following precautions for guarding themselves against similar disaster, whether from steam or gas. In the first place the safety-valves on the economisers should be at once examined to see whether they are working order, while it may be pointed out that a safety-valve of external dead weight pendulous construction, without wing or spindle, similar to those in use on many of the members' boilers, is less likely to become gagged by incrustation than the ordinary lever safety-valves boxed in out of sight, which are generally used, while in the second place the flues should be examined to see that there are no void chambers in which gas can accumulate, and care should be taken when either the economiser or bye-flue is shut off, that the damper at the entrance be closed as well as that at the chimney.

"SMOKE PREVENTION.

"As stated in last month's report, the attention called to the subject of smoke prevention by the late experiments conducted on this subject at Wigan by the South Lancashire and Cheshire coal owners, has led this Association to add to its staff the trained stoker who was engaged throughout the whole of the experiments just referred to, the object being that he might visit the works of the members, and assist their stokers in introducing a more smokeless system of firing. He has now been engaged in this way for about three months, and the following table may be of interest as showing the results arrived at:—

SMOKE PREVENTION RETURN FROM SEPT. 7TH TO DEC. 31ST, 1868.

| Index No. of Visits. | No. of Boilers at Work. | FIRE DOOR. | | FIRE GRATE. | | | COAL CONSUMPTION. | | | SMOKE PER HOUR. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Description. | Area of Perforation per sq. foot of Grate. | LENGTH. | Thickness of Bar. | Width of Air space between Bars. | Gross Consumption per week in tons. | Consumption per boiler per week in Tons. | Lbs. of Coal burnt per square foot of Fire Grate per hour. | Minutes of Very Light. | Minutes of Brown. | Minutes of Black. |
| | | | | ft. in. | | | Tons. | Tons. | | | | |
| 1 | 4 | Perforated. | 1.1 | 6.0<br>7.0<br>6.8 | 3/8<br>3/8<br>3/8 | 1/4<br>1/4<br>1/4 | 54 | 13.5 | 14.94 | 4 | 0 | 0 |
| 2 | 1 | Perforated. | 0.1 | 4.6 | 5/8 | 1/2 | 12 | 12.0 | 21.33 | faint | 2 | 0 |
| 3 | 3 | Square Opening. | 2.5 | 6.0<br>5.6 | 3/4<br>7/8 | 1/4 full<br>5/16 | 54 | 18.0 | 20.79 | 4 | 1 | 0 |
| 4 | 3 | Perforated. | — | 6.0 | 7/8 | 3/8 | 46 | 15.3 | 14.50 | 18 | 1 | 3 |
| 5 | 8 | Blind. | — | 6.0 | 1¼ | 3/8 | 172.5 | 21.5 | 23.00 | faint | pu | ffs. |
| | | | | ft. ft. | | | | | | | | |
| 6 | 19 | Blind. | — | 5 to 7 | vari | ous. | 340 | 17.9 | 20.70 | 8 | 3 | 0 |
| 7 | 4 | Slightly Perforated. | — | 7.0<br>6.0 | 7/8<br>7/8 | 1/4<br>1/4 | 65 | 16.2 | 16.28 | 17 | 0 | 0 |
| 8 | 4 | Perforated. | 2·0 | 6.0 | 1/2 | 5/16 | 60 | 15.0 | 17.77 | 12 | 4 | 0 |
| 9 | 1 | Perforated. | 0.3 | 3.7 | 1 | 1/2 | 6.1 | 6.1 | 23.33 | 7 | 3 | 0 |
| 10 | 4 | Perforated. | 1·4 | 7.0 | 1 | 1/2 | 69.8 | 17.4 | 17.47 | 9 | 8 | 2 |
| 11 | 4 | Perforated. | 0·3 | 7.0 | 3/4 | 1/2 | 61.2 | 15.3 | 13.96 | 52 | 8 | 0 |
| 12 | 4 | Perforated. | — | 6.0 | not | taken. | 90.0 | 22.5 | 23.80 | 24 | 2 | 0 |
| 13 | 4 | Blind. | — | 6.0<br>6.6<br>5.0 | 1¼<br>1¼<br>1¼ | 1/2<br>1/2<br>1/2 | 54.0 | 13.5 | 16.14 | 6 | 0 | 0 |

"From the above table it will be seen that the Association's stoker has visited 13 of the members' works, and operated upon 63 boilers, consuming per week 1,085 tons in the gross, and on an average, 17¼ tons per boiler; while the mean rate of combustion per square foot of fire grate per hour has been 18¾lbs. Under these conditions the average result has been realized of about 12½ minutes of very light smoke, 2½ minutes of brown, and one-third of a minute of black per hour, which is certainly very much below the amount emitted from chimneys generally. The conditions under which the trials were made were not by any means the most favourable for success. In some cases the doors had no perforations, in many the area was too limited, while some of the fire grates were 7ft. in length, which is too long. While no doubt more remains to be done to complete this movement, yet it has been seen that much can be accomplished by careful firing alone, coupled with the admission of a little air at the fire door, which shows the importance of having all fire doors fitted with suitable sliding grids on the outside, and perforated box baffle-plates on the inside.

"It has been found impossible to give this subject anything beyond the briefest notice on the present occasion, yet it is trusted the particulars given will be found of interest.

"In concluding this Report, the last of the series for 1868, it is satisfactory to be in a position again to state that no explosion has occurred to any of the boilers under the charge of this Association during the year, while to this it may be added that no boiler has ever exploded which this Association has guaranteed. This fact, it is thought, says much for the soundness of independent boiler inspection, and it is confidently trusted that the same return may be annually made if the members will but co-operate with the officers of the Association by accepting the suggestions made for their safety, as well as by affording facilities for the examination of their boilers, and intrusting them to the charge of ordinary competent men.

"The principle adopted by this Association is that of the most liberal inspection, and no boiler is guaranteed unless on a satisfactory annual examination, made when at rest, internally as well as in the flues. To accomplish this with so many boilers, and, at the same time, to make the examinations when the boilers can be best laid off, so as not to inconvenience the members, is by no means an easy matter, and has only been accomplished by making the utmost use of general holidays, as well as of local wakes, and other times of stoppage; and the Association would feel obliged to those members who cannot lay off their boilers at the ordinary periodical visits for 'entire' examinations, if they would avail themselves, as far as possible, of their own local holidays, rather than of the general ones, such as Christmas, Easter, and Whit-week, when there is a complete run upon the office for special visits. To meet these demands at all, it has been found necessary at such times to lay aside all the other duties of the Association, and for the whole staff to turn out as inspectors. In this way the number of 'entire' examinations for the past month, returned at the commencement of this report, viz.:—204 were accomplished, a considerable portion of them being made at the Christmas holidays, while similar advantage was taken of the stoppage of the works in New Year's week, the return of which, however, does not appear in the present report. The total number of 'entire' examinations during the past year has been 2,060, which is the very highest point ever attained since the formation of the Association, while as nearly as may be one out of every three examinations has been an 'entire,' which is the proportion desired. This result has been attained as will be readily understood at a considerable cost, but it has been thought better to expend the funds of the Association rather on careful examinations than in the payment of compensation. Competent inspection is found by experience to be a most expensive article, much more so than compensation, so that it would be to the advantage of the Association's exchequer to reduce its staff of inspectors, and carry a portion of the balance to the credit of the compensation fund, were not the fundamental principle of the Association the prevention of explosions, and the saving of human life.

"While no explosion has occurred during the past year to any boiler enrolled with this Association, 45 have occured outside its ranks in different parts of the country, by which 117 persons have been injured, 57 of them fatally. In 32 cases the scene of the catastrophe has been visited and a careful investigation made by officers of this Association, while the particulars of 5 others have been kindly supplied by engineers residing in the neighbourhood in which the explosions occurred, who have forwarded me sketches and details; while the remaining 8 were either unimportant, or occurred at so great a distance from Manchester as to render a visit inconsistent with a due regard to the other duties of the Association.

"In too many cases during the past year the investigations conducted by coroners in consequence of boiler explosions have been most unsatisfactory, and but little light has been thrown on the true cause of the disasters, and the stereotyped verdict of 'accidental death' has been given in almost every case, which has at least failed to stimulate any preventive measures, if it has not actually hindered them. Deaths from boiler explosions may be accidental legally, but they are not so mechanically. The inveterate habit still prevails of attributing almost every explosion to shortness of water, through the neglect of the attendants, though too frequently the poor fellows have been victimised by working bad boilers, the offspring of bungling boiler making, and commercial greed. It is most important that coroners should be empowered in all cases to call in competent engineering assistance, and that a searching examination should be made in each instance, as well as the truth plainly spoken. Were the press provided in this way with faithful particulars, and those who lead to the slaughter of their workpeople by the use of bad boilers, brought to the bar of public opinion, it is thought such a step would of itself do much toward the prevention of steam-boiler explosions which now recur on an average at the rate of one per week, and destroy from 60 to 70 lives per annum. The experience of the past year suggests as a corrective for boiler explosions, investigation and exposure."

## CHIEF ENGINEER'S MONTHLY REPORT.

The ordinary monthly meeting of the executive committee of this association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, January 26th, 1869, William Fairbairn, Esq., C.E., F.R.S., LL.D., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past mouth 116 visits of inspection have been made, and 276 boilers examined, 142 externally, 7 internally, 3 in the flues, and 124 entirely, while, in addition, 5 have been tested by hydraulic pressure. In these boilers 98 defects have been discovered, 9 of them being dangerous.

### Tabular Statement of Defects, Omissions, &c.

Met with in the Boilers examined from January 1st, 1869, to January 22nd, 1869, inclusive.

| Description. | Number of Cases met with. | | |
|---|---|---|---|
| | Dangerous. | Ordinary. | Total. |
| **Defects in Boiler.** | | | |
| Furnaces out of Shape | 1 | 2 | 3 |
| Fracture | 2 | 14 | 16 |
| Blistered Plates | ... | 11 | 11 |
| Corrosion—Internal | 1 | 13 | 14 |
| Ditto External | 2 | 18 | 20 |
| Grooving—Internal | ... | 9 | 9 |
| Ditto External | ... | ... | ... |
| Total Number of Defects in Boiler | 6 | 67 | 73 |
| **Defective Fittings.** | | | |
| Feed Apparatus out of order | ... | 1 | 1 |
| Water Gauges ditto | ... | 6 | 6 |
| Blow-out Apparatus ditto | ... | 3 | 3 |
| Fusible Plugs ditto | ... | 7 | 7 |
| Safety Valves ditto | ... | ... | ... |
| Pressure Gauges ditto | ... | 4 | 4 |
| Total Number of Defective Fittings | ... | 21 | 21 |
| **Omissions.** | | | |
| Boilers without Glass Water Gauges | 3 | ... | 3 |
| Ditto Safety Valves | ... | ... | ... |
| Ditto Pressure Gauges | ... | 1 | 1 |
| Ditto Blow-out Apparatus | ... | ... | ... |
| Ditto Feed back pressure valves | ... | ... | ... |
| Total Number of Omissions | 3 | 1 | 4 |
| Cases of Over Pressure | ... | ... | ... |
| Cases of Deficiency of Water | ... | ... | ... |
| Gross Total | 9 | 89 | 98 |

"Several instances of internal corrosion were met with, and it may be pointed out that where this action is going on, it is very important to have the heads of the rivets, as well as the edges of the overlaps, well sounded with a hammer, as they are often treacherously rotten, while they appear to the eye to be only a little wasted.

"Several cases were met with in which boilers were corroded externally, just under the bottom of the shell, and at the front end, in consequence of slacking the ashes in front of the boilers, and it is recommended, in order to give as little room for the corrosion to harbour has possible, that the cross wall at the front of the bottom flue should not be more than 4½ or 9 inches in thickness, while it would be well to have this removed—which could be done with but little expense—in preparation for the annual entire examination. Also this wall should, in all cases, be recessed, so as to pass behind the blow-out elbow pipe.

"One boiler just enrolled with this Association was found on its first examination to be corroded all the way along the midfeather wall on which it was set, and so severely reduced in one part as to be only one thirty-second of an inch thick, so that the inspector readily pushed a chisel through it.

"One instance of a most defective set of fittings was met with in the case of a boiler brought for the first time under the notice of the Association. There were three boilers of peculiar construction, somewhat, but not precisely, like the 'elephant,' or French boiler, set side by side. On each of these there were the remains of the brasswork of two glass water gauges but there was not a single glass in one of them. Neither was there a float nor gauge tap, and our inspector saw two of the boilers working in this dangerously equipped manner. Added to this, the mudhole and manhole covers were most insecure, and as these were pointed into the firing space, very much like the muzzle of a loaded gun, the firemen have anything but an enviable position, especially since the boilers are usually worked at a pressure of 95lb. per square inch, and the valves are loaded to 100lb. Our Inspector took care not to stand in front of these covers, and declined the offer of the attendant to get steam up to blowing-off point. It should be explained that these boilers are not enrolled with this Association, but the Inspector examined them under mistake, in consequence of the insufficient address given by a new member, whose works he had to visit for the first time. The owner of these gaugeless and dangerous boilers was recommended to put them under inspection, but he did not appear to appreciate the advantages of this, having his own views both as to boiler construction and management.

"Explosions.

"On the present occasion I have two explosions to report, by which four persons were killed and two others injured, while, as one of these occurred to the boiler of a locomotive engine, it may not be an inappropriate occasion to give the particulars of another explosion which occurred to a boiler of the same class a few months since, but which there has not hitherto been an opportunity of entering on. Not one of the explosions under consideration occurred to boilers enrolled with this Association. The following is the tabular statement:—

### Tabular Statement of Explosions,

From January 1st, 1869, to January 2nd, 1869, inclusive.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 1 | Jan. 2 | Single-flue, Cornish, Internally fired | 4 | 2 | 6 |
| 2 | Jan. 11 | Locomotive, Internally fired | 0 | 0 | 0 |
| | | Total | 4 | 2 | 6 |

"No. 1 Explosion, by which four men were killed and two others injured, occurred at a colliery at about daybreak, on Thursday, January 14th.

"At this colliery there were two boilers set side by side, and connected together. One of these was of the Cornish class, having a single flue tube, in which the fire was placed, running through it from one end to the other, while the other was of plain cylindrical, egg-ended, externally-fired construction. The boiler that exploded was the Cornish one, set to the left hand of the other, and measuring 26 feet in length, 6 feet in the diameter of the shell, and 3 feet 2 inches in that of the furnace tube, while the thickness of the plates was three-eights of an inch in both cases, and the load upon the safety valve 45lb. though the steam sometimes rose to

50lb. when blowing hard. The boiler was fitted with two efficient open lever safety-valves, as well as with a steam pressure gauge, a mushroom blow-out valve, a feed-back pressure valve, one water gauge tap, and an ordinary wheel float.

"An officer of the Association visited the scene of the catastrophe a day or so after the explosion happened, and on examining the boiler found that it had failed in the furnace tube, the crown having come down immediately over the fire, and rent transversely for a length of about 4 feet at a patch close to the second ring seam of rivets from the front end, the plates having bulged down till the one behind the rent rested on the fire bridge, and the one in front on the fire bars. From the large opening thus formed a torrent of steam and hot water rushed out at both ends of the furnace tube, blowing up the brickwork setting at the back, and moving the boiler slightly forward on its seat, while the rush of water at the front carried away some of the furnace bars, and led to the serious cases of personal injury through scalding already enumerated, and referred to more particularly hereafter.

"The cause of the explosion does not admit of question. The local character of the collapse, which was confined entirely to the crown of the furnace tube immediately over the fire, as well as the appearance of the tube altogether, plainly showed that the explosion was due to overheating of the plates through shortness of water.

"This view is corroborated by the narrative of the explosion given by those at the works to the Association's inspector, as well as by the report of the coroner's inquest, which it is thought are of sufficient interest to justify a reference being made to them. From these it appears that the boilers were worked night and day, and that the night engine tenter left the one in question at about six o'clock in the morning with the water at the usual level, and the donkey engine at work pumping into it. At ten minutes before six the day engine tenter examined the float for himself, when he found there was a depth of about 6¼ inches of water above the furnace crown, while the donkey engine was still feeding, which he allowed to go on till a few minutes after six. He then attended to his engines till about a quarter past seven, that is to say, for a little more than an hour, when he paid another visit to the boilers, and on testing the float on the Cornish one, found that it fell down to the tube, showing that the furnace crown was bare. On discovering this, he called to the enginewright who, according to the colliery rules, was the man to be appealed to in cases of emergency, and consulted with him as to what should be done. On this the enginewright tested the float himself and recommended immediately drawing the fires rather than blowing off the steam as the engine tenter proposed. At this the engine tenter at once began to rake out the fire, and persevered till severely scorched by the hot embers, when the enginewright pushed him aside, saying 'Let me have a go at it,' and set to work himself, taking the rake in one hand, while with the other he shielded his face from the intense heat, the fireman meanwhile standing alongside throwing water on the burning mass as it was drawn out. While this was going on, the son of the colliery proprietor came and stood behind the enginewright, when, just as he had cleared the grate almost to the bridge, the furnace crown collapsed, and the torrent of hot water, rushing out of the furnace mouth, blew the poor man backwards to a distance of 25 yards, rake in hand, and so severely injured him that he died almost immediately; in addition to which, the son of the colliery proprietor, standing behind him, and the fireman, slacking the ashes, were so severely scalded that they died shortly after, while three others at the pit's mouth, about twenty yards off, were also scalded, one of them fatally.

"A scientific witness, who gave evidence at the inquest, took the same view of the matter as that already given, viz., that the collapse had arisen from overheating of the furnace crown consequent on shortness of water, but added that 'the explosion was, therefore, evidently attributable to inattention on the part of the attendants,' and the jury brought in a verdict of 'accidental death.'

"While there can be no question that the collapse, as just stated, was due to shortness of water, it is thought that the conclusion that it was attributable to inattention on the part of the attendants by no means exhausts the subjects. It has long been the practice to cast all the blame of explosions on boiler attendants, and though this course may be found convenient at coroners' inquests, in order to prevent further inquiry, it has by no means the effect of preventing further boiler explosions, which should be the object of all such investigations.

"It should not be forgotten that the only means with which the attendants were furnished for ascertaining the water level, was an ordinary wheel float placed on the top of the boiler, while it was necessary for the fireman to make a journey round to the back of the boiler, in order to test it and see that it had not stuck fast, which the scientific witness just referred to said might at any time occur if the gland through which the wire passed was screwed down a little too tight. The glass water gauge, with which this boiler was onced furnished, had been allowed to go entirely to ruin, and only a fragment of the bottom remained, while out of three gauge taps the two upper ones were stuck fast and useless, and the lower one, which was about 9 inches above the level of the furnace crown, and thus too high to be of much service, was generally used for drawing off hot water. As a further illustration of the neglect with which the boiler was treated, it may be stated that it had not been examined in the external flues since transplanted about four years since to the colliery at which it exploded, although set on a midfeather wall of the excessive thickness of 18in., the brickwork of which was found to be damp, so that there is every probability that the plates are corroded, while it is certain that a boiler under these circumstances cannot be worked on without examination except at a great risk of life. It appears that the glass water gauge had been in the dilapidated state just mentioned for some three or four years, so that the boiler had been worked on most improperly both as regards the shell and equipment for some time.

"There is no positive evidence as to how the shortness of water occurred —whether from neglect of the feed supply, or whether from leakage at the fittings or any other part; but however this may have been, it must be clear that instead of affording the boiler attendant but a single float, which might only mislead unless tested in each case by hand, there should have been a couple of glass water gauges fixed to the front of the boiler so that they might be right before the eyes of the fireman every time he charged his furnace. Had such been the case in the present instance, there is every probability that the shortness of water would have been detected in time to have prevented the explosion. Added to this, had there been a low-water safe-valve, the steam would have been blown off as soon as the water fell below the desired level, and thus have given warning of the danger, when, if this had been neglected, the valve would have continued to allow the steam to escape until all the pressure was relieved and collapse rendered impossible. Hundreds of these low-water safety-valves are working satisfactorily on the boilers under the inspection of this Association, they are constantly found to do good service, and their adoption in the present instance would doubtless have prevented the explosion and saved the four lives sacrificed by it.

"To deal fairly, therefore, with this catastrophe, and to learn from it all that it teaches, something else should be concluded than that it was due to 'inattention on the part of the attendants.' The boiler was allowed to work on by its proprietor with a dangerously disabled set of fittings, and thus it is thought he must at least share the responsibility of an explosion which scalded four men to death, and injured two others.

## SOCIETY OF ENGINEERS.

### INAUGURAL ADDRESS OF THE PRESIDENT MR. F. W. BRYANT, C.E.

(*Concluded from page* 42).

In India, again, what a great revolution engineering is effecting in that vast empire, and what an immense amount of work there is yet to be done in every branch of our profession. And, from what I can learn, there is now a great want of engineers in India, preventing works already proposed being carried out. There are many difficult problems in engineering to be solved, one, I may mention that appears to be more than ordinarily so, and which has yet to be overcome: I allude to the bridge over the Hooghly, which has taken up the attention of many engineers for some time past without any practical result. Still there are works progressing of very great extent, in which there are many difficulties, taxing the skill of the engineers in every way. Take, for instance, the Great Indian Peninsula, the Bombay and Baroda, the Great Southern of India, and other railways, the dock and harbour works at Bombay and other parts of India, the progress of which we get reported to us from time to time.

Telegraph engineering is extending most rapidly, and ere the end of this year we may expect that the French Atlantic cable will be laid, forming another link between the old world and the new. And I believe that the time is not far distant when we shall have communication by telegraph with China and Australia. One seems to suggest the other, as it would doubtless be *viâ* China that a telegraphic line to Australia would be laid. Then there are the North Sea cables, which will be connected with an overland cable and carried on to India through Prussia, Russia, and Persia. More particularly concerning us here is that our Government will in all probability this year arrange that the Postmaster-general will have complete command of the telegraphs in this kingdom, which will be of great importance and value to the public in general, and I hope to see before long telegraphy as cheap as postage.

Engineering goes hand in hand with civilisation, and, as we have seen, the rapid alteration railways have made in changing the aspect of towns and villages in England, and even the manners and customs of their inhabitants in many ways, so can we imagine the great alterations that will take place in India when railways become common and good roads and bridges abound in every locality. These alterations will probably extend to China, and that curious race become more civilised, better known to us, and their barbarous customs discontinued.

In Australia also engineering is progressing. There are even now many large works necessary for the benefit of its inhabitants generally, and as the population increases will become absolute necessities.

In America, since the late sad warfare has ended, engineering has made a brisk recommencement in many places, and I learn on good authority that the great question of the junction of the Atlantic and Pacific Oceans by a ship canal across the Isthmus of Darien is again mooted, and that the American Government have actually sent a gentleman of high position to make negotiations and inquiries respecting its being carried out. Our "Transactions" for last year will contain in papers read by Dr. Cullen an excellent account of all that has been done with regard to this grand project.

In railway and bridge works American engineers have proved themselves remarkable for their boldness of design and rapidity of execution. Take, for instance, the suspension bridge thrown across the Niagara river last year, which has the tremendous span of upwards of 1,260ft., or nearly double the width of the centre span of the late Hungerford Suspension Bridge. And we read of still greater spans as being proposed and probably carried out. Then there is the proposed bridge over the Mississippi at St. Louis, which will be a novelty in bridge building, as it will consist of three arches constructed in steel, the centre span of which will be 515ft. or some 35ft. wider than twice the span of the centre arch of Southwark Bridge. Some of the railways have been constructed with great rapidity (although it must be borne in mind that the style of work is totally different to that prevailing in England), and great ingenuity has been shown by the manner in which American engineers have passed their railways over most difficult countries. Both in North and South America there is a vast field for engineering enterprise in all its branches. Also in Canada it is known there are many important works required that sooner of later must be carried out.

I have not perceived anything particularly novel that has been introduced into civil engineering of late, although I must not forgot to mention the fact that, instead of building docks abroad, they are built at home, and sent abroad to be placed in position. I instance the Bermuda floating dock, built in the Thames, now lying in the Medway, which leaves for its destination early this year; also a floating dock for Bombay.

In foundations—which are the most important studies of an engineer—cylinders and screw-piles seem to be the favourite methods at present for bridge foundations, piers, and other works in water. In the London district it seems the general opinion that for large buildings it is necessary to go down to the London clay for a foundation. I cannot perceive the absolute necessity for this, and I think in many cases it might be avoided at a great saving in cost.

In mechanical engineering improvements in detail appear to be constantly made.

The great question as to the manufacture of steel seems to be still in dispute. We have not yet seen it used for any structure of importance in England at present, although I think it is probable we may do so before long. In cases where lightness is required with strength it might be used very advantageously.

Hydraulic engineering has advanced to great perfection. Photography, which has been much improved during the last year, has proved invaluable to the engineer in illustrating the progress of works. Electricity—the most wonderful of all things applied for the use of mankind—has not yet been successfully used as a motive power; a single idea might revolutionise the whole of our present practice. Civil engineering is the application of natural philosophy, and it is by studying the great laws of nature that we may hope, no matter by how small advances, to improve our profession.

In conclusion, let me particularly urge upon you, the members and associates of this Society, the necessity of earnestly working for its advancement. By becoming members you show that it has your good wishes; but it wants more than good wishes, it wants your working assistance to further its objects. By attending its meetings you show a disposition to support those who are working for it; and by contributing papers, a willingness to give the knowledge you possess, not only to the Society, but to the profession generally.

## ON THE APPLICATION OF STEAM TO THE CULTIVATION OF THE SOIL.

By Baldwin Latham.

(*Continued from page* 42.)

### 2nd. Class.—Locomotive Engines travelling on Fixed Railways.

To the extraordinary success which attended the working of the railway system of this country, no doubt, is due the idea of extending the system to agricultural operations in order to aid and assist in the development of agricultural enterprise; and it must be admitted that this system, when adapted to all the modern appliances for steam culture, affords great facilities for executing a large amount of work with economy and despatch, and so far it may have realised the sanguine expectations of its inventor.

The first invention relating to ploughing, in which other motive power than that of horses is used, and in which the railway or guide rail is introduced, is the invention of Messrs. Clarke, Freeman, and Varley in 1846. The invention consists in the application of a pneumatic tube placed between the rails, similar to the arrangement adopted in the atmospheric railway. The apparatus for exhausting the tubes is intended to be placed in a central position on the estate to be operated on, and the whole estate is then to be divided into rectangular plots, in such away that it shall be intercepted with main or branch lines leading direct from the central station; from these branch lines other subsidiary lines are to diverge at right angles. These subsidiary lines are to be placed about a quarter of a mile apart, and the power is to be communicated from the atmospheric tubes to locomotive engines travelling of these subsidiary lines; by this arrangement "each set of ploughs, or other agricultural implements," are intended "to be worked by two locomotive engines placed on opposite sides of the plot of ground to be tilled, and communicating with the exhausted branch pipes at the sides of such plot. The ploughs (which are fixed in a diagonal line across the plough frame) are drawn over the land in opposite directions alternately, by means of two ropes or chains, fastened to opposite ends of the plough frame, and connected to a drum on each locomotive engine; one rope being unwound as the other rope is wound upon its drum."

In the same year (1846), but at a later period, John Tulloh Osborn took out a patent for "machinery for tilling and draining land, to be actuated by the power of steam, water, or air, or by animal power." The description of engine he proposed to use, consisted of an ordinary agicultural engine, as manufactured at that period, and carrying two drums for the purpose of hauling the cultivating implements. This invention has been considered of such importance that it is quoted in the specifications of some of the leading steam-plough makers of the present day. The plan of working comprises the use of two locomotive engines which "traverse the land on temporary rails, laid in parallel lines, at right angles to the direction in which the furrows are to run—the distance between the two lines of rails varying from one hundred to two hundred yards." As already stated, each engine has two drums; and attached to these drums are the chains or ropes that haul "two four-wheel carriages, fitted with ploughs or other implements," which travel simultaneously across "the field in opposite directions—each carriage pulling after it the rope or chain by which it is to be drawn back again. Thus, while one drum on each engine is at work winding up its ropes and so putting the ploughs or other implements in motion, the other drum is delivering out its rope in readiness for the return operation. After each traverse of the ploughs or other implements, the engines are moved forward by means of a chain or rope, one end whereof is attached to an anchor laid out ahead, and the other end to a drum connected with the crank shaft of the engine."

The invention of Sir J. S. Lillie, in 1847, which has already been alluded to, embraced under one head a mode of applying rails in order to facilitate the movement of his traction engine.

In 1850, Lord Willoughby de Eresby introduced his system of steam ploughing. The machinery consisted of the "California" locomotive engine, designed by Sir Daniel Gooch, which weighed 3½ tons, and was twenty six horse power. The engine was fitted with a double capstan, which could readily be removed when the engine was required for other purposes. It was intended by the inventor of this system that the engine should be moved "across the centre of the field on a light portable railway. The ploughs advance and recede on either side of the railway at right angles to it. The ploughs, or other implements of culture, are intended to be worked by "an endless chain 150 yards in length, which will be put in motion by the capstan of the engine. Provision is made at the moving anchor for taking up the slack, or letting out fresh chain; and by this arrangement the chains could be varied a length of forty feet to suit the varying length of irregular shaped fields. The ploughs that were intended to be used consisted of "four ordinary ploughs and the like number of subsoil ploughs fixed in a frame," which were to be guided "by a person standing on a small platform" attached to the frame. Two such sets of ploughs were intended to be worked "one on either side of the railway." The ploughs alternately advance and recede, the advancing plough being at work, while the other is being drawn back ready for work when the advancing plough has completed its furrow; and, as the work of ploughing progresses, the engines and anchors are moved forward in order to operate on fresh land. The author of this invention states, that this machine "would perform the work usually done by sixteen ploughs driven by as many men, and drawn by thirty-two horses." The steam machinery, he states, would require the attendance of eight men, and a horse to draw water for the engine; it would, therefore, save the labour of eight men and thirty-one horses; but against this must be set an expense of five shillings a day for coals, as well as the per centage upon the value of the machinery, say three shillings per day, upon an original cost of 450*l.* to 500*l.*

In 1855, Peter Alexander Halkett introduced his guide rail system of cultivation. The system consists in so arranging a number of guide rails as to divide the land to be cultivated into a number of rectangular plots about 30 ft. in width. And the machinery, which is to operate on the land, is arranged on a platform the whole width of the space between the rails, which platform is supported and propelled by wheels which move on the fixed rails. The invention is applicable to "ploughing, scarifying, sowing, reaping, or other operations of culture." Owing to the permanent and fixed character of the rails, "the implements are, in their operation, always kept at a regulated height, independent of the small undulations or unevenness of the ground, or of the firmness or softness of the soil; and whereby they are also kept from varying to the right or the left of the line of onward motion." In addition to the line of permanent way that traverses the field, fixed rails are laid along the headlands of the fields; and by a suitable arrangement the platform with its machinery is transferred from one line of rails to the other. The ploughs are so arranged that but one-half of the area between the rails is supposed to be ploughed up; the other half is presumed to be either in crop or fallow. The ploughs in this system are arranged in two sets "to act alternately in opposite directions—one set being raised out of action while the other set is in operation." The great advantage of this system, but which does not apply to any of the ordinary systems of rail as before described, lies in the fact that all the operations of culture are guided by the fixed rails; the ploughing, cultivating, sowing, hoeing, watering, and reaping. are all capable of being performed; and, as the seeds sown are distributed with mechanical precision, the subsequent operations of hoeing, trimming, or watering can be carried on in the space between the growing crops with the utmost certainty and safety, and without at all interfering with them. Although the machine used in this system, in which rails are provided for the guidance of the traction power, does answer and perform all the operations required in the cultivation of the soil, there are two strong reasons why the system will never become universally applied. The first is the question of cost, which alone must debar the system from general adoption, because a system that shall require for permanent rails a cost of from 10*l.* to 30*l.* per acre is not likely to come into general operation when it is seen that, as a rule, the farmers' profits will not suffer any great outlay. The other reason against the adoption of this system lies in the fact that the fixed rails and sleepers will occupy a large area of land which may otherwise be usefully occupied and cultivated; and therefore it is probable that these reasons will powerfully operate and prevent the development of this system on an extended scale.

Of course there may be cases where temporary rails may be, and are, used for the guidance of the ordinary agricultural locomotive engine, especially in bad weather and soft soils; but it has not been the author's intention to allude to those temporary expedients of getting over a difficulty, but to illustrate those inventions that at the outset were started with a view of making use of a system of rails more or less of a permanent character. Those temporary expedients of bridging over a soft place by means of planks or rails need no exposition from the author, as they are but the natural expedients that have occasionally been resorted to when carrying out the ordinary modes of steam cultivation hereafter to be referred to.

### 3rd Class.—Fixed Engines.

The plan of working apparatus for the cultivation of the soil from stationary engines is one of the earliest methods that has been proposed for applying power for the purpose of assisting in the various agricultural operations carried on by the farmer. The chief exponent of this system at the present day is Mr. William Smith, of Woolaston: but the honour of originating the system cannot be claimed for him, as we have inventions older in date than the experiments of Mr. Smith, which he only commenced in 1854. Although the place as original inventor of this system cannot be claimed by Mr. Smith, yet he is deserving of all praise for the care. skill, and unremitting attention that he has given to this system when in its infancy; and, under his fostering hand, he has had the satisfaction of seeing it developed and pretty generally employed. The plan of cultivating the soil from fixed appliances has had from time to time a fair share of the thought and skill of the inventor.

The first application of power transmitted to implements from fixed engines or machines is seen in the various early inventions for draining land by means of ploughs. Thus, in 1800, we have the invention of Richard Lambert for drain ploughs, consisting of a carriage carrying two winding drums, which are intended to be worked by six or eight men; and when at work the carriage is held by an anchor and struts, while the men give motion to the drums, which wind up the draught chain attached to the plough, and so draw the plough forward.

In 1809 nearly the same arrangement of working was patented by Mark Dobits, and again in 1810 by George Hickford, and in 1819 by Tew Cowper.

The first invention that had for its object the application of a fixed source of power for cultivating the soil is contained in a patent taken out, in 1839, by Henry Pinkus, which has been before alluded to; but a portion of this patent had reference to "engines" which, "instead of travelling over the land and drawing the implements after them, may be used for giving motion to endless chains or ropes to which the implements are attached;" and the author of this invention had a very clear notion of the value of this mode of working in very hilly country, and therefore did not fail to recommend its adoption, and point out the way in which the invention could be carried out; for he says, "where a roping system may be so applied on the steep inclinations of hilly lands, a well-known system of pulleys, called the differential pulley, may be combined with the said impelling engine." The differential pulley was patented, about seven years before this invention of Pinkus's, by Joseph Saxton, and the object of the arrangement consists in using wheels or pulleys of different diameters in such a way as to take advantage of the results obtainable by the difference in diameter, so that a considerable velocity may be given to implements in cultivating the soil, while the rope transmitting the power moves through a comparatively small space.

In 1841, Conrad Frederich Stollmeyer proposed a mode of "obtaining power from the wind and waves by means of sails, windmills, and floats, or buoys, and applying the power so obtained" for working machinery for the cultivation of the soil. In this invention the power is transmitted by the aid of wire ropes, which are coiled several times round a drum to preserve them as far as possible from slipping when at work.

In 1844, Messrs. Stace and Vallance secured letters patent for an "application of wind power by means of portable windmills or machines, to drawing or working ploughs, and some other agricultural implements and carriages used in agriculture, such as harrows, rollers, scarifiers, clod-crushers, drills, horse-hoes, drain-ploughs, mole-ploughs, thrashing machines, winnowing machines, chaff-cutters, and other implements that can be worked by power given off from rotatory motion." In the ordinary cultivation of the soil, the implements are attached to an endless rope, which in its course passes around our shifting pulleys, and is put in motion by two portable windmills, placed at opposite corners of the field." The rope, after leaving the first windmill, "passes to a pulley on the same side of the field, thence across the field, to a pulley on the opposite side, and onward to the second windmill; from this machine it proceeds to a second pulley on the same side, then passes across to the second pulley on the opposite side of the field, from which it returns to the first windmill." One portion of this invention is deserving of especial attention, as in it we have the first exemplification of the clip-drum principle, which, in 1859, was patented by Messrs. Fowler and others, and which is so deservedly popular for all purposes requiring security and great traction force In this invention of Messrs. Stace and Vallance, the rope is grasped by a lever carrying a weight, the force of which is conveyed in increased power owing to the leverage with which it acts on the ropes, which it grasps with a fixed amount of force. Although in this invention a lever and weight are used, it is easy to see that a number of springs, or one central spring, attached to the lever arms of the pulley, might be used; and thus we should have a clip pulley, which holds the rope so long only as the pressure of the springs or weight is more than the strain on the rope.

In the clip-drum on Fowler's principle, with the increase of strain on the rope the pressure is increased by the clip which holds the rope; this, in many cases, is a great advantage; but, in ploughing by steam, it is often found that the implements may strike suddenly against a stone, or the root of a tree, when a sudden strain is brought to bear on the rope and implements; and, in consequence, some part of the implement or the rope must give or break. Now a clip-pulley, so arranged that the grip on the rope may be something less than the strain that would permanently injure the apparatus, would release the rope and allow it to run freely round the pulley without injury or breakage of the machinery.

In 1850, R. Cotgreave procured a patent for a drain-plough that was to be worked by an "ordinary capstan or windlass placed at a distance from the trenching machine and connected thereto by means of ropes or chains."

In the same year Mr. John Fowler took out his first two patents for drain ploughs; and there is no doubt that, to the success attending the improved drain ploughs of Fowler, the present success of steam cultivation is due. We have seen in all the late Mr. Fowler's undertakings an energy and perseverance that has commanded a well-merited success. In 1852, Mr. Fowler introduced the steam-engine as the motive power of the drain plough; and, when so applied, the manifest advantages of applying the same power in an analogous way became manifest; and in the report of the judges at the Royal Agricultural Society's meeting at Lincoln, in 1854, after extolling its merits and describing its performance, they are led to say that, "Surely this power can be applied to more general purposes; we earnestly commend the idea to our engineers and machinists." The idea, once started, was not long in being taken up, and hence we find, after this period, a number of inventions all tending to train the great power of the steam-engine for the purpose of cultivating the soil.

In February, 1854, an invention of T. Atkins, which combined some of the leading features of the stationary engine system, received provisional protection. The invention was for "improvements in transmitting power and communicating motion to implements for agricultural and other purposes." The power was proposed to be derived from "water, wind, steam, heated air, or any combination of these or any other agents;" and the prime mover was to be either "locomotive or stationary." In connexion with the engine he proposed to attach a "grooved wheel, which,' was "to be surrounded with an endless rope or cord, whether made of metal, hemp, cotton, or any other elastic material." This rope or cord was to communicate at the proper distance with an apparatus called by the inventor "a rope cart," and this cart was "provided with pulleys, wheels, and other mechanism, to secure a steady strain for transmitting power," and so communicate the power to another carriage to which cylinders, "studded with spades, prongs, knives, teeth, or such other implements as the work to be done may require," were attached.

In 1855, J. A. Williams, farmer, of Baydon, Wilts, obtained letters patent for "improvements in machinery or apparatus for driving or actuating ploughs and other implements employed in working and cultivating land." These improvements consisted in the application of the ordinary type of portable engine acting by means of a specially constructed framework carrying all the necessary winding drums and apparatus for working the ploughs. In this arrangement "the ploughs or other implements for cultivating and working the land are attached to a small carriage, giving them an independent action from the strain of the chain or rope, one end of which is connected to the said carriage, whilst the other is wound round one of the drums—the free end of the other rope or chain on the second drum, when ploughing with one-way ploughs, being attached to an intermediate rope, fitted with swivel hooks or eyes; and this rope is connected at its other end to the hauling carriage." A fixed table, secured to the side of the machine and engine next the ploughs, contains a row of holes at distances asunder equal to the width of the furrows. In these holes is successively fixed the axis of a movable guide pulley round which the hauling rope is passed, after being previously passed round suitable fixed guide pulleys or rollers secured to the framing or table of the machine. A movable guide roller is fitted into a movable trussel under this table to prevent the rope from rubbing "against the edge thereof, and to guide it into the horizontal guide pulley. A somewhat similar table and movable guide rollers, forming part of a framework on travelling wheels, with small adjustable guide pulley, is firmly fixed at the opposite end of the field by suitable shores or struts, embedded firmly into the ground. A large fixed horizontal guide pulley is attached to this last-mentioned table or framework, round which pulley is passed the intermediate rope hereinbefore referred to." In ploughing or cultivating with this apparatus one or more furrows are intended to be ploughed at once, the number depending upon the number of ploughs that may be employed; and the apparatus is capable of drawing a plough either from or towards the engine. The arrangement is such that, after the ploughs have traversed one section of the land, the movable guide pulleys are intended to be advanced a certain number of holes on the framework referred to, the distance moved depending upon the number of furrows or the breadth of ground at one time intended to be ploughed. In the specification of Williams' patent, the first mention is made of the use of rope porters for the purpose of preventing "the ropes from chafing against the ground."

In the year 1855, Messrs. D. and T. R. H. Fisken, introduced a system of steam cultivation, the principle of which has of late been advocated by several inventors. The invention of Messrs. Fisken, consists in use of a very light rope travelling at a considerable velocity, and working suitable winding apparatus on the cultivator or plough which, acting upon a properly moored rope, draws the plough, or other implement at a slower pace across the field; or, in the words of the inventor, the power from the steam-engine or other prime mover is transmitted to the machine by an endless rope of a sufficient length to suit the length of the field, and the distance of the motive-power engine. This rope passes under a small guide pulley or sheave (upon the ploughing machine), and over a large driving wheel, upon the axis of which are keyed two toothed pinions, in one of which a less number of teeth is cut than in the other. These pinions gear into other and similar pinions, and serve to impart motion to a spur wheel, upon the axis of which is keyed a drum, round which a strong wire rope or chain is partially wound; this wire rope or chain after passing under two guide pulleys (carried by the ploughing machine), is fastened at each end to anchor, constructed for the purpose, and placed at opposite sides of the field or piece of land to be ploughed or otherwise operated upon. When the endless rope is set in motion, the resulting action of the drum against the wire rope or chain causes the machine with the ploughs or other implememts to be drawn across the field." The slack of the quick moving rope is intended by the inventor to be taken up by "a small flying capstan." The arrangement, by which the power is transmitted to the implement, is as follows: "From the steam engine, which is situated at one end of the field, the rope proceeds along the side of the field to the flying capstan, secured at the opposite end; after passing round the pulley or sheave on the capstan, it returns along the side of the field till it comes to a double-grooved pulley on the carriage of the anchor to which one end of the wire rope, for hauling the cultivator is attached;" from this anchor it passes across the field to the other anchor, to which the other end of the hauling rope is secured; after passing round a pulley on this second anchor carriage, the rope "returns across the field to the first named anchor carriage; and from the pulley of this carriage it proceeds to the steam engine, passes round a pulley or drum driven thereby, and thence again to the flying capstan." When ploughing, and in order to cultivate fresh land, the anchor carriages are moved by the winding up of a chain or rope which is sent forward and fastened to an anchor or stake, the other end being secured to a small drum to which the requisite motion is imparted by its being connected with the pulley driven by the endless rope. It will be seen from the arrangement that, by moving the "flying capstan," the slack of the rope may be taken up, or the distance between the anchors may be increased, without diminishing the efficiency of the invention.

In 1855, P. A. Halkett, whose guide rail system has been already mentioned, proposed, amongst other methods of propelling his cultivating apparatus over his guide rails, the use of a "stationary engine or other power placed at the headlands, and motion communicated to the platform by means of a rope or ropes."

In the latter end of the year 1855, A. D. Lacy invented a steam plough, and proposed a method of working which has some merits. It may be called the double stationary engine system. The engines each carry a winding drum and rope, and are placed at opposite corners of the field. The wire ropes for working the implements are attached to each end of them, and afterwards passed round properly mounted anchor pulleys, whence they proceed to the winding drums of their respective engines. One engine is intended to be at work winding up its rope, while the other one is paying out the rope from its winding drum. The special merit of this system lies in the fact that it requires but one half the length of rope necessary to cultivate the same area on the single engine and roundabout system as at present practised, and consequently, so far as the ropes are concerned, will be cheaper and more economical in working, because there is a smaller amount of resistance in the ropes and less friction; and moreover, with a shorter length of rope, the chances of breakage and other casualties are considerably reduced.

The year 1856 was a remarkable year in the annals of steam cultivation, for in this year patents were secured by Messrs. Fowler, Smith, and Howard; and the machines and apparatus then introduced are still successfully worked at the present day. The first patent in this year was taken out by the late John Fowler, on the 3rd of January, and consisted in a mode of applying the power of a stationery steam-engine to a double capstan, so as to haul ploughs for the cultivation of the soil. For the purpose of carrying out this invention two drums were intended to be fixed on the same frame, and so arranged that when one drum was winding up the wire rope the other drum was unwinding it. The rope was afterwards passed over two guide pulleys fixed on the ground, and the implement was intended to be worked backwards and forwards between these guide pulleys. In order to cultivate the whole of the land the guide pulleys were moved from time to time as required.

On the 11th of the same month a patent was taken out by Mr. H. Smith, which had for its object "improvements in ploughs and other cultivating implements which are put in motion, when in use, by steam or other power actuating a barrel or barrels on to and off which ropes are wound." These improvements consisted in the means and appliances by which the implements could be turned at the headlands, and in which the first action of the draft rope, when the engine was reversed, was to turn the plough or other implements; for this purpose the two ends of the ropes were both attached to the fore part of the plough by means of a drag link.

In April of the same year Mr. Smith procured provisional protection for an invention but the patent is now void. The invention consisted in fixing the winding drums of the stationary engine on a frame mounted on two wheels, and constructed with shafts to receive a horse, the general arrangement being similar to that of Howard's patent windlass. In this invention of Smith's two winding drums were intended to be used, "which are capable of turning independently of each other freely on the axle of the carriage," and which are intended to be "driven alternately" by the stationary engine. It should be here mentioned that the first windlass used by Smith was made by Messrs. Ransomes, under the direction of the late Mr. Fowler.

In May, 1856, Messrs. Howard procured their first patent for the application of steam power to the cultivation of the soil. This invention consisted in the use of a number of "turn wrest" ploughs attached by chains to a travelling frame, which was intended to be driven by means of a wire rope passing over a number of guide pulleys "set at opposite corners or other points of the field, and thence" proceeding "to the winding on and off barrels of the engine." The pulleys in this invention were intended to be fixed by means of a sort of screw or cork-screw anchor, and rotatory guides were used "to assist in the laying of the rope or chain upon the windlass." Another portion of this invention had reference to the attachment of ploughs to a locomotive engine; but, as this method of cultivation as been exploded, it is not necessary to refer to this portion of the invention.

In 1856 Messrs. Chandler and Oliver procured a patent for a mode of fixing the drum used in steam cultivation. It consists in fixing a drum for holding the band, strap (traction rope), or chain employed with engines for ploughing and other agricultural purposes, upon the axle of the fore or hind wheels of the travelling engines now employed in connexion with agriculture. Or we convert either fore or hind wheels into drums, by raising them, by means of blocks or otherwise, from contact with the ground, and by screwing, bolting, or otherwise attaching flanges to the sides of the wheels, in order to prevent the band slipping off from them.' From the arrangement of these drums it will be seen that the plan proposed is only adaptable for stationary engines, and that with these the increased width of the machine, caused by the space occupied by the drums, will render it somewhat unmanageable in narrow roads and gateways.

In 1857 J. Fowler procured a patent for a method of working ploughs. This invention consisted in mounting the "drums on separate axes placed at an angle to each other," and also in a method of "moving the pulley anchor along the headlands, by the power of the engine acting through the same rope as that which draws the plough." Those anchors consisting of "plates or discs of metal, which can be drawn through the land with much greater facility in one direction than in the other. The rope from the winding apparatus passes first over a stationary pulley, and then over the movable pulley on the headland, from which it passes at right angles to the plough; thus, when the strain is on the tackle there is a tendency to draw the anchor of the movable pulley towards the fixed pulley. To overcome this tendency the anchor of the movable pulley is secured to an additional or supplemental anchor, which prevents it from moving while the plough is travelling; but when it is wished that this anchor should be drawn along the headland, it is only necessary to slacken the tackle which secures it to its supplemental anchor, and then the strain on the rope which draws the plough will cause it to move forward." A further portion of the invention had reference to the use of stationary posts to which pulleys which carry the rope were attached. In this patent the first mention is made of travelling rope porters, which the inventor intended should be used "between the two pulleys on the headlands."

In 1857 Edward Hayes obtained letters patent for an improved windlass to be used in conjunction with a stationary engine, the object of which was to obviate the necessity of stopping and reversing the engine at every turn of the plough or other cultivating implement. The apparatus consisted of a rectangular iron frame mounted on road wheels; across this frame a strong hollow iron shaft is fixed, and two winding drums are mounted so that they can turn loosely upon the shaft. On one side of each of the winding drums a projecting ring is formed, and on the inside thereof are teeth into which a toothed pinion gears; this pinion is mounted on an axis carried by a bracket securely keyed upon the hollow shaft, which carries the winding drums, and it has also at its other end a toothed wheel, which gears with and receives motion from a pinion formed on the side of a belt pulley mounted so as to turn loosely on the hollow shaft already mentioned. When this apparatus is at work it is placed near a steam-engine, and a belt from the driving pulley of the steam-engine passes to this belt pulley, or to the corresponding pulley which drives the other winding drum; and between these two driving pulleys there is a third pulley for receiving the driving belt when it is required that the two winding drums should remain stationary. The driving belt as it passes from the engine to the driving pulleys passes through a forked guide mounted on a bar, placed across the frame and capable of sliding for a short distance, from side to side laterally; this bar has three notches formed in it, into either of which a locking bolt can drop, so as to retain the bar in position when the fork is opposite one of the three belt pulleys. In connexion with the locking is a trigger, to which a string may be attached and led to any part of the field, so that by pulling this string the locking bolt may be withdrawn by a person stationed at a distance. When the locking bolt is removed, the fork bar is, by means of springs or weights, caused to traverse a distance so as to shift the belt on to the loose pulley, and the same movement of the fork bar allows the same or other springs, or weights, to bring breaks to act on the winding drum; but when the fork bar is worked by the band lever, so as to throw one of the driving pulleys again into a gear, the same motion of the bar removes the break from the drum to which that driving pulley gives motion." The invention also includes a mode of distributing the rope evenly on the winding drum, which consists in passing the rope "through guides to which a to-and-fro motion is given, by means of a pinion mounted on a shaft, which is driven by a screw on the boss of the winding drum." In principle the arrangement of this windlass is similar to that of a heavy planing machine. The great advantage possessed by this arrangement of windlass must be admitted when it is seen that there is no stopping the engine, therefore no temptation to the driver, when the engine is stopped, to keep it idle; one man can manage the engine and windlass, and each anchor man, by an arrangement of cords stretched over the ground, can instantly stop the plough or cultivator. Therefore, by means of this arrangement, ploughing or cultivating can be carried on by moonlight or in fogs with great security.

In 1858 Messrs. Fowler procured two patents; the first had reference to the construction of the frame containing the winding drum, which was so arranged that the hind wheels of the ordinary portable engine could be removed, and the firebox let down into an opening made in the frame. The portable engine "rests in front on its own wheels, and behind on the wheels" of the frame containing the drums. Another portion of this invention had reference to taking up the slack of the rope, which will be considered hereafter. The other invention of this year had reference to turning the implements at the headlands by the action of the traction rope; and consisted in attaching the rope "near one of the hinder corners of the implement," and leading it round the back and along one side to the front, at which point it is held by a clutch when the implement is at work. When it is desired to turn the implement at the headland "the traction rope is released from the clutch, and it then in unwinding itself from the implement turns it half round, so as to reverse its position ready for the next traverse over the land, at the same time it winds the return rope partially round the implement, and when this is made fast in the clutch, it is ready to become the traction rope." Another portion of this invention had reference to the arrangement of portable engines with winding drums for hauling ropes. Instead of the two winding drums being arranged "in the space under the boiler between the fore-wheels and the hind-wheels, one only of the drums is in this position," and the other is placed "between the two fore-wheels immediately over the locking motion." One drum only is "driven by the engine, and the rope is passed" several times round "the pair of drums in an oval coil;" "but in order to obtain sufficient bite on the rope, which it is difficult to do with this arrangement, the rope which ordinarily is led away from the loose drum is again passed round the driven drum, and is brought out between the two drums. By this arrangement, in whichever direction the engine be winding, the rope passes on to the driven drum before it comes on the loose drum."

In 1859, Messrs. Fowler obtained a further patent for improvements in steam ploughing. The first portion of these improvements referred to implements, and the latter portion to taking up the slack of the rope at any time that may be required; but one portion of it related to the means of giving motion to "tilling implements by steam power," for which purpose "an engine having two drums mounted on it on horizontal axes, these drums being so constructed that the hauling rope may be passed several times over them, and then be led away from them."

In 1860, Collinson Hall introduced a number of improvements in steam tilling apparatus, which will be considered when treating of the details relating to ropes and rope porters.

In 1861, Messrs. Howard obtained letters patent for improvements in steam cultivating apparatus; these improvements had reference to the construction of an improved windlass, to be used in carrying out what has been called "Smith's" or the "roundabout" system; and they state that "hitherto it has been the practice, when throwing the winding drums out of gear, to use two distinct motions—the one for disengaging the driving pinions from the drum teeth, and the other for applying a brake to the released drum to prevent the too rapid running off of the rope. Now, the object of this invention is to bring the brake into action on its drum simultaneously with throwing the drum wheel out of gear with its driving pinion;" and for this purpose the winding drums are to be mounted "on eccentrics, through which an axle passes loosely, and is secured to the windlass frame. The outer side of each drum carries a ring of teeth cast upon a projecting flange; into these teeth the pinions respectively take. The shaft of these pinions has its bearings in brackets carried by the main axle and framework. From the inner side of each of these brackets project brake blocks, which project under the flange of the adjacent drum. Attached to the eccentric of each drum is a lever, by means of which the eccentrics can be turned on their axis, which movement raises the drum teeth into gear with the driving pinion or lowers the drum, and thus throws it out of gear. As the drum is lowered, the inner face of its flange comes in contact with the brake block, and the weight of the drum being thus thrown on the brake block, the requisite friction will be obtained." The windlass is intended to be "mounted on a pair of travelling wheels," and to secure it in position for working, cutting blades are "temporarily attached to the ends of the driving shafts," which, "being forced into the ground," securely anchor the windlass.

In the same year Messrs. Howard took out another patent, but it became void through non-compliance with the letters patent in neglecting to file a specification. This invention related to the mode of transmitting the rotary motion of a steam engine to the windlass by means of flexible coupling.

In March, 1862, Messrs. Fowler procured a further patent for improvements in steam cultivating apparatus. In addition to improvements in their well-known implement, the improvements had reference to the mode of constructing "a winding windlass for hauling cultivating implements." The nature of the invention, consisted in arranging the apparatus for guiding the winding of the rope on a windlass fixed on a vertical axle, "so that in whatever direction the rope is being wound from the guiding apparatus, it readily adjusts itself to its proper position." The improvements also had reference to arranging, when required, the windlasses of cultivating apparatus in such a way that they are at liberty to "swing partially round at an angle to each other or to the carriage or engine to which they are attached, so that they may adjust themselves to the line of the hauling rope;" or, in some cases, the engine boiler, to which the windlass is attached, is made to swing to adjust the winding windlass to the line of draft.

In April, 1862, Messrs. Howard introduced further improvements in the windlass to be used in the Smith system of cultivation, the object of which was to economise the power when driving the windlass. It has been found that, with windlasses constructed to pay off and take up the hauling rope from two drums, a brake is required to check the too rapid paying off of the rope; and so the brake blocks, which have already been alluded to in a former invention of Messrs. Howard, were introduced. Now, it has been found that these brake blocks did not answer the object they were intended to effect, and moreover were the cause of a considerable loss of power; therefore this invention of Messrs. Howard had reference to a mode of making the two drums act in concert by means of a frictional appliance, which consists in a pair of revolving discs or rollers, so applied that in throwing "the barrels in and out of gear, that barrel which for the time is to give off the slack rope shall, when it falls out of gear, bear upon its disc or roller." The barrels of the winding drum have annular recesses cut in the adjacent ends, and it is in the recesses that the discs or rollers are "simultaneously in contact with their respective barrels (one being in contact with the inner, and the other with the outer surface of their respective annular recesses), the driven barrel will cause the roller of the slack-rope barrel to regulate the speed of its barrel, and allow it to rotate only at a given relative speed by reason of the friction of contact between this roller and the loose barrel."

In July, 1862, Alexander Leslie procured a patent for a mode of working implements differing somewhat from the general plan of working as now adopted and partaking more of the nature of Fisken's mode of propelling the implement. The author of this invention proposed to employ an endless rope which, instead of hauling the implement as in the ordinary mode of steam cultivation, was to give motion to a wheel fixed on the frame of the cultivating implement. This wheel geared into others, and they again gave motion to the driving wheels of the implement, which by preference were armed with spikes or projections in order to take hold of the ground and propel the implement to which the ploughs were intended to be attached. This system of hauling cultivating apparatus by means of a fixed steam engine has been very generally adopted, and it is some advantages that will commend it to the attention of the agriculturist, and which will be hereafter considered.

In concluding this section of the subject, it is only necessary to add that many of the inventions that have been described are applicable to the system of locomotive engines moving along the headlands, as will be seen by reference to that system, which will be hereafter described. The chief makers of this class of implements have already been mentioned, and it may here be said that there are a number of other firms, who work under license, and construct the special implements of the different inventors.

(*To be Continued*)

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## THE INSTITUTION OF CIVIL ENGINEERS.

### THE MAURITIUS RAILWAYS—MIDLAND LINE.

By Mr. JAMES R. MOSSE, M. Inst. C.E.

Before proceeding to the special object of this communication, which was to give an account of the working of some unusually heavy gradients, the chief physical features of the island, and the causes that led to the introduction of railways in the colony, were briefly noticed. The necessity for railway communication being felt by the local government, Mr. J. A. Longridge, M. Inst. C.E., was in May, 1858, charged by the Secretary of State for the Colonies to investigate the subject, and having reported in favour of the railway system, the construction of the works was authorised by the Imperial Government in May, 1861. Mr. Hawkshaw (Past-President, Inst. C.E.), who had previously reported on the railways by order of Govcrnment, was appointed Consulting Engineer, and in September, 1861, a contract was entered into with Messrs. Brassey and Wythes for the execution of the works, which were commenced early in 1862, under the direction of Mr. Walmesley Stanley, M. Inst. C.E., as Chief Resident Engineer, and of Mr. Longridge as Agent for the Contractors. The north line starting from the central station at Port Louis traversed the northern and north-eastern portions of the island, and was 31 miles in length; while the Midland line commencing at the same station in Port Louis passed nearly through the centre of the island, and was 35 miles in length. The only work of importance on these railways was the Grand River Viaduct, a description of which had already been given to the Institution (Min. of Proc. Inst. C.E., Vol. XXV., p. 237). The North line was opened for public traffic on the 24th May, 1864, and the Midland line on the 19th October, 1865. Land had been purchased and all the masonry had been built for two lines of way; but at present the iron work for the superstructure of the under girder bridges and the permanent way had only been provided for a single line. The total cost of these railways had amounted to £21,876 per mile.

The character of the Gradients on the Midland line would be understood from the following summary: From Port Louis to the summit, there was a rise of 1817ft., the distance being about 16 miles, or equal to an average gradient of 1 in 46·68; and from the summit to Mahebourg, a distance of about 19 miles, there was a descent at the rate of 1 in 55·61. For about 12½ miles before reaching the summit the inclination was on an average 1 in 41·17, and thence for about 13½ miles the line fell on an average 1 in 45·06. The steepest gradient was 1 in 27, of which there was a total length of 13,526ft., the greatest continuous length of this gradient being 6,163ft., and the next longest 5,016ft. The next in severity was 1 in 30, the total length being 9,526ft., the greatest length of this gradient being 3,000ft., and several lengths of about 2,000ft. each. The ascending gradients varied from 1 in 27 to 1 in 60, while the descending gradients towards Mahebourg varied from 1 in 30 to 1 in 60. The curves varied from

950ft. radius to 6,000ft. radius, and the lengths of these curves ranged from 200ft. to 3,200ft. The ordinary radii were generally from 2,000ft, to 3,000ft. The sharpest radius which occurred on the steepest gradients of 1 in 27 and 1 in 30 was 1,600ft.: the greatest continuous length of this curve being 900ft. on the former gradient, and 1,930ft. on the latter. The next radius in severity was 2,000ft. on the maximum gradient of 1 in 27, the greatest continuous length of this curve being 1,000ft. Reverse curves of this radius 1,920ft. in length were also found on the maximum inclination of 1 in 27. On descending from the summit to Mahebourg, the line from the 17th mile to the 19th mile might be said to be composed wholly of reverse curves; and at the 29th mile the radius was only 1,400ft., the length of this curve being 1,980ft., chiefly on a gradient of 1 in 30. Of curves under 2,000ft. radius there was an aggregate length of 21,165ft.; of those ranging from 2,000ft. to 4,000ft. radius there was a length of 49,710ft.; and of curves from 4,000ft. to 6,000ft. (the greatest radius), there was an aggregate length of 25,560ft., the total length of curves being 96,435ft., and of the straight portions of the line 89,467ft.

The locomotives furnished under the original contract for working these inclines were seven in number, and of the following description:—they were tank engines, having cylinders 16in. in diameter, with a length of stroke of 22in.; the wheels, six in number, were 3ft. 6in. in diameter, and were all coupled, the length of the wheel base being 15ft. When supplied with water and fuel, these engines weighed nearly 37 tons, and they were worked with a pressure of steam of 120lbs. per square inch. Subsequently six larger saddle-tank locomotives were designed by Mr. Hawkshaw, having the following dimensions:—cylinders 18in. in diameter, with a length of stroke of 24in.; the wheels, eight in number, were 4ft. in diameter, and were all coupled, the length of the wheel base being 15ft. 6in. When supplied with water and fuel, these engines weighed nearly 48 tons, and they were worked with a pressure of steam of 120lbs. per square inch. The centre pairs of wheels (one of which was the driving pair) were fixed stiff on the frame; but in order to pass easily round the curves, both the leading and the trailing wheels had ⅝ of an inch play on each journal, and the joints of the coupling rods, connecting these wheels with the driving pair, were fitted with a ball and socket, so as to allow the requisite motion. All the engines were manufactured by Messrs. Sharp, Stewart and Co., and worked very satisfactorily. These engines would, with passenger trains, take five carriages and one break-van, equal to a load of 42 tons, though on some occasions they had hauled eight loaded vehicles, weighing in all about 56 tons; while with goods trains the usual load with the lighter locomotives was 70 tons, and with the heavier locomotives from 100 tons to 120 tons. It should, however, be stated, that by reducing the lead of the slide valves to one-eighth of an inch, the power of these engines had recently been increased 10 per cent. The average speed of the passenger trains, including stoppages, was 12 miles per hour between Port Louis and the summit, and 15 miles per hour from Mahebourg to the summit; while that of the goods trains was about 9 miles an hour, including frequent stoppages. The particulars of a trip made on the 12th December, 1867, when the fuel and water were noted more accurately than usual, were given in detail. From these it appeared that the train consisted of ten loaded wagons weighing together 83 tons, or with the engine a gross load of 131 tons; the average speed from Port Louis to the summit was 11 miles per hour, and taking the average pressure of steam in the cylinder as 60lbs. per square inch, the power exerted would be $\frac{131 \times 60 \times 12 \times 88}{33,000} =$ 230 H.P., or not including the weight of the engine 146 H.P., and this divided by the weight of the locomotive was equal to 3·04 H.P. per ton of motor. The coal used on the above trip was obtained from Sydney, N.S.W., and the consumption amounted to 4·75lbs. per H.P. per hour, 8lbs. of water being evaporated by 1lb. of coal, but ordinarily only 7½lbs. of water were evaporated by 1lb. of this coal.

With the exception of the first-class carriages, all the others on this railway had a Break on every wheel, worked from the inside. The ordinary passenger trains were composed of one first, one second, and two third-class carriages, with one break-van, and to these trains Mr. Clark's continuous break was attached. This apparatus was worked by a chain, which tightened the breaks on every one of the wheels simultaneously. The breaks were taken off by heavy counter-balance weights, resting longitudinally over the chain in the centre of the carriage, between the front and end wheels. This apparatus was sufficiently powerful to lock every wheel, and had worked satisfactorily; for during two years there had not been a single fracture of the chain, nor of any of the working parts. It, however, required careful management, and must be applied gradually, before the train had acquired serious momentum. The break-van of every passenger train was now provided with sand boxes leading to the rails, as formerly the dew on the rails wetted the wheels of the break-van, and prevented the friction rollers of the apparatus from revolving; whereas, as soon as sand was applied, the wheels became dry, and the friction rollers acted efficiently. Every train of four or five carriages had two guards, one to work the continuous break, the other to use the separate break, if necessary, attached to that carriage which was not the continuous break. The heaviest passenger train which had descended from the summit to Port Louis consisted of fourteen carriages and two break-vans, conveying five hundred and thirteen troops. This was on the 14th November, 1868, and it was kept perfectly under control by the continuous break on four carriages, and by five additional breaksmen, the speed being steadily maintained at 20 miles per hour. There were but four instances of passenger trains getting for a time beyond control:—first, one morning when the rails were wet, a train descended from the summit for a distance of 3⅝ miles in five minutes, or at a speed of 45 miles per hour. This was the highest speed on record, and it occurred before the sand boxes were put on the break-vans. Secondly, in a similar way, another train attained a speed of 32 miles per hour. Thirdly, a train over-ran a station for a considerable distance, chiefly from the want of sufficient care on the part of the engine driver and guards. Lastly, a train once attained an excessive speed in descending from the summit, through the dropping off of the nut of the eyebolt passing through the axle on which the continuous chain of the break apparatus was wound. The speed in descending the inclines was limited theoretically to 18 miles per hour, practically it rarely exceeded 25 miles, and the carriage breaks were generally sufficient to control the train, without the necessity of applying the engine break. The goods trains in descending the inclines as a rule consisted of eight loaded wagons with the lighter locomotives, and of ten or twelve wagons with the heavier engines: and in these cases also the breaks on the wagons, two being screw breaks and the remaining wagons being furnished with the ordinary lever breaks, afforded power sufficient to control the trains. It had long been in contemplation to make Safety Sidings at the foot of the steepest inclines, but the ground was by no means favourable for the purpose, and, moreover, it was feared that such sidings might become a source of danger.

The rules in force for the regulation of the traffic on the main line and at the stations were then given in detail, as well as the traffic returns for the years 1866 and 1867, the rates for passengers and goods, and the statement of the receipts and expenditure for the year 1866, from which latter it appeared that the working expenses were then 62½ per cent. of the receipts; but this result was said to be due to several exceptional causes. Considering the high price paid for skilled labour and for fuel, the agricultural character of the district through which the line passed, the severity of the gradients, the want of anything that could be called a town save at Port Louis, the lack of minerals or manufactures to transport, the peculiar nature of the sugar traffic—requiring a large amount of rolling stock for three months in the year, whereas for the remaining nine months less than half the quantity sufficed—the Author thought it was not surprising that the working expenses of the Midland line should in 1866 have been 62½ per cent. of the receipts, or 5*s.* 5*d.* per train mile. Now that the heavier locomotives enabled a larger amount of sugar to be carried, and when the goods traffic was further developed, it was believed a considerable decrease in the per centage of working expenses to receipts would ensue, accompanied also, it was hoped, by a reduction in the cost per train mile.

In conclusion it was remarked, that although it might sometimes be impossible to construct a railway with easier gradients than those on the Midland line, yet the difficulty of working these inclines in wet weather had been so great the load hauled so small, and the speed so low, that the Author thought the severity of any gradient for a long rise should never exceed 1 in 40; and that it would be always preferable (under the ordinary system of tractive power), to incur, within reasonable limits, any additional expense that might be requisite to bring the inclination within this ratio. It was also suggested that in laying out such inclines, whatever might be the ruling gradient, (provided it was not entirely exceptional, and where additional power could be applied,) that gradient should be followed throughout the line, as far as the features of the country would permit. It was likewise recommended, that pieces of level should be introduced between the different inclinations, as they were of the greatest value, in controlling the trains in descending. The Midland line had now been opened for more than three years, and fortunately no accident had yet occurred to any train in descending the inclines.

The Appendix contained a summary of the gradients and curves, the details of the locomotives and schedule of the rolling stock, the imports and exports in Mauritius from 1860 to 1866, the population, revenue and expenditure of the island, and the immigration returns between the same dates, a memorandum of the steam machinery and of the value of labour and materials in the island, and meteorological observations taken at Port Louis in 1865.

At the meeting of this Society on Tuesday, the 2nd ult., Mr. Charles Hutton Gregory, President, in the Chair, fourteen candidates were balloted for, and declared to be duly elected, including four Members, viz.: Mr. Joseph Haywood Watson Buck, Resident Engineer of the Standedge Tunnel Works, on the London and North Western Railway; Mr. Thomas Dale, Engineer of the Corporation Water Works Hull; Mr. Peter Greck, Chief Engineer for Railways in the Imperial Russian Service; and Mr. Henry Johnston Wylie, Westminster. Ten gentlemen were elected Associates, as follows: Mr. John Bowden, Deputy Borough Surveyor, Salford; Mr. Alfred Mountain Fowler, Borough Surveyor, Leeds; Mr. Charles Hart, Parsonstown; Mr. Bleamire Moody de Michele, Resident Engineer, Recife Drainage Company, Pernambuco; Mr. Joseph Musgrave, Bolton; Mr. Eyre William Preston, Assistant Engineer on the Great Indian Peninsula Railway; Mr. Alfred Lewis Sacre, Manager of the Yorkshire Engine Works, near Sheffield; Mr. Harco Theodorus Hora Siccama, Engineering Staff of the London and North Western Railway; Mr. Augustus Horace Strongitharm, Assistant Engineer, Furness Railways; and Mr. Joseph William Wilson, Craven Street.

It was also announced that the Council had recently admitted the following Candidate a Student of the Institution: Joseph Pomfret Van der Meulen.

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## DESCRIPTION OF THE NEW FERRY AND THE NEW BRIGHTON PIERS AND LANDING STAGES, ON THE RIVER MERSEY, NEAR LIVERPOOL.

By Mr. Henry Hooper, Assoc. Inst. C.E.

The ferry accommodation of the river Mersey having been briefly noticed, it was stated that in order to provide a means of communication by water between the central and the southern portions of Liverpool and New Ferry on the opposite shore, the Mersey River Steam Boat Company was originated, to run steamers from the Prince's Stage to the south end of the borough, and thence across the estuary to New Ferry.

This necessitated the erection of a Pier, with landing stage and connecting bridge, at New Ferry, which was constructed from the designs of Mr. Brunlees, M. Inst. C.E., by Messrs. W. and J. Galloway and Sons, under the superintendence of the Author. The Pier consisted of fourteen spans, each 58 feet in the clear. It was formed of three lines of wrought-iron girders, placed 9 feet apart from centre to centre, and resting on cast-iron columns. The openings were arranged in three groups, the first, from the retaining wall towards the river, comprising five bays, then two rows of columns, next four bays and again two rows of columns, and lastly five bays, terminated by a platform, 18 feet by 16 feet, supported on a cluster of eighteen columns and piles. The girders were each 60 feet in length, 4 feet 9 inches in depth, and of the ordinary lattice form, footways of Memel planking being carried on the bottom flanges. The two footways were each 8 feet 4 inches in width, and were assigned respectively to the traffic passing in opposite directions. The top member of the girder was composed of two half-round bulb irons, forming, when rivetted together through the flanges, a tube of 8 inches external diameter. The two outside girders were each calculated to bear a load of 120 lbs. per superficial foot of platform, and the centre girder was nearly twice the strength of the others. The supporting columns were 12 inches external diameter, the metal being three-quarters of an inch in thickness. They were generally cast in lengths of 10 feet, and were connected together by flange joints, excepting the junction of the columns with the piles, which was of a socket form. The piles were cast in variable lengths, to suit the contour of the ground; they were furnished with one turn of a screw at the bottom, 2 feet 6 inches in diameter, the metal being $1\frac{1}{4}$ inch in thickness at the root, and the top of each pile was of a plain spigot form. The piles were screwed down to depths of from 6 feet to 10 feet by means of capstans.

The outer edge of the platform at the head of the pier formed a bearing for the moveable joint at the upper end of the Bridge connecting the pier with the floating stage. This joint allowed a horizontal and vertical motion of the bridge, and consisted of a strong wrought iron girder, having a radial motion round a steel pin, 4 inches in diameter, fixed to part of the framework on the top of the columns. The vertical motion was obtained by means of a hinge under each girder of the bridge, composed of a wrought-iron forging, bolted to a rotating girder, and a steel pin, $2\frac{1}{2}$ inches in diameter, passed through it and the two forged straps rivetted round the end of the bridge. The under side of the rotating girder immediately beneath these hinges was supplied with two sheaves, or rollers, bearing on segments fixed to the heads of the columns. The Bridge was 158 feet in length, and was formed of two bowstring girders on the lattice principle, 10 feet in depth at the centre, and placed 9 feet 8 inches apart. The girders were kept in place at the bottom by T irons, and at the top by an arch of wrought iron. The lower end of the Bridge was suspended by chains from a wrought iron cradle fixed on the floating stage. This was considered necessary, to reduce the strain on the Pier and Bridge, caused by the rolling of the stage, and was found to answer very well. The platform of the Pier was 12 feet above high water of ordinary spring tides, and 7 feet above an extraordinary tide of 21 feet.

The floating stage was 100 feet in length by 22 feet in breadth, tapering for a length of 19 feet to 19 feet at each end. A spur, 22 feet by 11 feet, projected at the back under the bridge. The pontoon was 7 feet 3 inches in depth, and the sides had a batter inwards of 1 foot. It was built of ribs of T iron, and was divided into five compartments by four watertight bulkheads. To increase its stiffness, there was a longitudinal bulkhead along the centre of the pontoon, and smaller bulkheads under the cradle supporting the bridge. The deck and appurtenances were of the usual description. The stage was moored by four chains, two at each end of the pontoon. Each chain was 50 fathoms in length, and at right angles to the adjoining one, the end of each being secured to an anchor with one fluke. Provision was made for taking in the slack of the chains by two sets of gearing, fixed on the stage, one at each end. The pontoon drew about 2 feet of water, and at low water of spring tides there was never less than from 7 feet to 8 feet of water at the front of the stage.

The dimensions of the various parts of the structure were given in detail; and with regard to the expenditure upon the works, it appeared that the approaches cost £1.063, the pier (including the bridge) £7,740 and the stage £2,674, making a total of £11,477.

The design for the New Brighton Pier and Landing Stage was of a similar character to that of the New Ferry Pier, and was likewise furnished by Mr. Brunlees, the original contractors being Messrs. Rothwell and Co., but the works were finally completed by Messrs. Bowdler and Chaffer.

The Pier consisted of three lines of wrought iron girders, each 60 feet in length, the number of bays or spans being twelve, divided into three groups of four spans each, by two intermediate rows of columns. The enlarged platform at the river end of the pier was 33 feet 6 inches by 16 feet, and was supported by short wrought iron girders, resting upon a cluster of twenty vertical and thirteen raking cast iron columns, 12 inches external diameter, the metal being three-quarters of an inch thick. The screw piles were 2 feet 6 inches in diameter, and had a pitch of 7 inches. They passed through variable depths of from 5 feet to 8 feet of sand and gravel to the surface of the rock underneath. The width of the pier from centre to centre of the outside girders was 21 feet 4 inches; the centre girder dividing the platform into two footways, each 10 feet in the clear, the girders forming the parapets.

The Bridge connecting the pier and stage was 160 feet in length; the two girders were 11 feet apart from centre to centre, leaving a clear footway of 10 feet 3 inches. The upper end of the bridge had a similar motion to, and the lower end was hung by chains from a wrought iron cradle on the same principle as, that at New Ferry.

The Floating Stage was 200 feet in length by 30 feet in breadth, and consisted of a series of twelve pontoons, connected by three lines of lattice girders and two lines of box keelsons. The end pontoons were pointed so as to act as cutwaters, and were each 29 feet by 18 feet; the ten intermediate pontoons were 29 feet by 11 feet 6 inches, and the depth of all the pontoons was 6 feet 3 inches. The stage was finished in the usual manner, and was provided with all necessary fittings.

The dimensions of the various parts were given in detail, and in conclusion it was stated, that the total cost of the pier, bridge, stage, and subsidiary works had amounted to £23,906.

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## ON THE LAGOONS AND MARSHES OF CERTAIN PARTS OF THE SHORES OF THE MEDITERRANEAN.

By PROFESSOR D. T. ANSTED, F.R.S.

The author commenced by alluding to the relations of physical geography and geology to engineering, and proceeded to describe the state of the Rhone, its delta and the tract called the Camargue. He remarked that the actual delta was limited to the west by the stream of the Vidourle, and to the east by the Crau; its extreme breadth being 40 miles, and its area 180,000 acres; and he noticed that while the main stream had gradually been shifting towards the east, the pseudo-deltaic formations subordinate to it had been rapidly advancing towards the west and south. He then alluded to the condition of the Rhone current, and the evidence that the delta had advanced outwards towards the sea within the historic period by a distance measured by miles. The mode of formation of the delta was described as follows:—Sand, drifted by marine currents from the south-east from beyond the mouth of the Rhone, formed mounds or dunes, at places where fresh water running down from the land met the salt water. The dunes increased in number along a line parallel to the shore, till they formed an imperfect border to brackish-water lagoons. During summer the dunes became connected, and in the rainy season breaches were caused by the sea. At length, a complete barrier was effected, and a nearly fresh-water lagoon was formed. The same work was then repeated, and the lagoon was filled up, more or less completely in the course of time, by warping, so that a permanent addition was made to the land. The largest lagoon of the delta (that of Valcares) was next described. It covered 25,000 acres, and was protected by an artificial sand dyke, $16\frac{1}{2}$ miles long, completed in 1857. The other works executed, with the exception of some locks and canals to keep open channels to the sea, were very slight.

Details were next given of the great system of lagoons extending beyond the true delta of the Rhone to the Cape of Agde, a distance of nearly 40 miles, which the author believed to be of no great geological antiquity. Beyond the delta the district consisted at first of the tertiary deposits, near Montpellier, then of the jurassic formations of the ridge of the Gardéole, and finally of the basaltic rocks, continued from Central France, and which terminated at the Cape of Agde.

The lagoon of Mauguio, the first beyond the Vidourle, had an area of 8,000 acres; its greatest depth was 4ft. 7in., and the level of the water was 8in. below the Mediterranean in summer. It communicated with the sea by only one opening, and was separated from it by a sandbank at first $1\frac{1}{2}$ mile wide, gradually narrowing to 500 yards or 600 yards. Towards the land were extensive marshes, and all the villages around were very unhealthy. It received the drainage of about 78 square miles, by a number of streams, the longest of which was about 13 miles. This lagoon was nearly separated from the next (the lagoon of Pérols) by a tongue of land, beyond which came the drainage of a stream (the Lez). The lagoon of Pérols, and the next in order, that of Grec covered about 3,300 acres, of which about 2425 were under water, the rest being marsh. The maximum depth of water was only 33in. below the summer water level, which was 7in. below the Meditterranean. The marshes around were about 10in. above the water level. These lagoons received little water from the land immediately around. They had been fed almost entirely from the drainage area of the Lez, now conducted by canals direct to the sea. The drainage area of the Lez was 125 square miles, but the effect of rain was rapid and considerable, owing to the form of the ground, and the extremely heavy showers that sometimes fell. There were three lagoons between that of Grec and the great lagoon of Thau, the total water area being 11,280 acres. They received the drainage of about 33 square miles of country, and the physical conditions accounted for the lagoons. The lagoon of Thau covered 20,000 acres, its only natural outlet being at the extreme south. It received the drainage of about 120 square miles of country. The works projected for the improvement of the sanitary condition of the coast, and the recovery of the marsh lands, were next alluded to and were stated to be on the whole satisfactory.

Attention was then directed to the lagoons of the East Coast of Corsica. These were derived from the detritus brought down by the rivers from the mountains. The Golo was the chief river, and the lagoon of Biguglia the largest lagoon. It extended north of the Golo, its length being $7\frac{3}{4}$ miles, and average breadth for 6 miles 1,000 yards. Beyond this, to the north, was a narrow neck of water communicating with the sea. The total water area was 4,750 acres; the maximum depth was 4ft. 6in., and the mean depth $33\frac{1}{2}$in. It was separated from the sea by a sand bank, 900 yards wide near the Golo, and 400 yards at the other end. During storms the waves washed over it at two points. The water was sometimes fresh, and sometimes salt. The drainage area supplying water to the lagoon was 70 square miles, but it was made up of three parts—one between the Golo and the river Bevinco, the principal feeder—the next, the drainage area of the Bevinco—and the other, a small space of ground supplying water to the neck beyond the Bevinco. The author then explained the history of the lagoon, and pointed out that by separating the district, and conducting the waters of the Bevinco to the sea, the condition of the larger part (about 4,000 acres) was not at all unfavourable for complete drainage. He compared the case of the Bevinco to the that of the Lez, on the coast of Languedoc; and pointed out that there was historical evidence rendering it probable that the Bevinco had only recently added its waters to the lagoon of the Biguglia, owing to the gradual advance of the dunes that inclosed the latter, and that the coast was comparatively healthy, and was inhabited, before this event took place. He mentioned that the case of the other lagoons along the coast was similar generally to that of the Biguglia; but that each needed separate consideration, according to the physical geography of the district.

Rainfall statistics both of the coast of Languedoc and that of Corsica were then given, from which it appeared that the average rainfall on the coast of France, near the delta of the Rhone, was about 36in., and of the coast of Corsica not more than 24in. for the years of observation. The extremes, were however, very great, and the mean annual fall was of little value for practical work. The seasonal falls were also given, and some particulars of heavy rain on both coasts.

The author concluded with the following summary of the practical bearing of the facts adduced:

*First.* That the malarious lagoons and marshes, of which there were so many examples on various shores, were the result of the interception of waters coming off small tracts of land, or of small and torrential streams, by banks of drifted sand and mud, proceeding from larger rivers, carrying out to some distance large quantities of detritus which was distributed by marine currents.

*Secondly.* That a study of the existing physical geography of each district affected by malaria, combined with a knowlege of its geology, was sufficient to explain the conditions, and to determine the history of the operations that had terminated in the formation of the malarious marshes and lagoons.

*Thirdly.* That the removal of malaria, whether to be effected by complete drainage or by partial drainage, accompanied by the keeping certain lagoons in free communication with the sea, could only be hoped for by engineering operations, based on the special history of the case under consideration, as determined by a knowledge of the physical geography and geology of the district.

*Fourthly.* That, in certain cases where small torrential streams had been kept back from the sea by the rapid accumulation of drifted sand, the drainage of the marshes and lagoons might be rendered comparatively easy by keeping open a permanent channel for such streams.

*Fifthly.* That the principle of breaking up the drainage areas supplying water to the lagoons into smaller areas, each of which admitted of separate treatment, being suggested by the history of lagoons generally, was the principle which should be adopted in all cases where sanitary improvement was called for, and would generally be found advantageous in an economic sense.

## WIRE ROPE TRANSPORT.

Some interesting experiments have lately been made at Bardon Hill, near Leicester, to test the merits of an invention which has recently been patented by Mr. Hodgson, C.E. The invention has for its object the construction of light and cheap ways for the transport of mineral or agricultural produce in localities as yet unprovided with railways. The system may briefly be defined as a continuous development of the plan not unusual in India, Australia, and in some mining districts, of bridging over a river or ravine by a single wire rope, by which, carried in a bucket suspended by a pulley, the necessary loads are transmitted from one point to another. To accomplish the easy passing of the points of support necessary to carry out a continuous line of communication, and to provide for the distribution of the burden and the application of motive power, have been problems of no small difficulty; but, after experiments on a first trial length of half a mile, during the autumn of last year, these practical details were worked out, and a contract was immediately entered into for a line of three miles in length near Leicester, which has recently been completed, for mineral traffic. This line consists of an endless wire rope, supported by a series of pulleys carried by substantial posts, which are ordinarily about 150 feet apart, but, where necessary, much longer spans are taken, in one case amounting to nearly 600ft. This rope passes at one of its ends round a Fowler's clip drum, worked by an ordinary portable steam-engine, and the rope is thus driven at a speed of from four to six miles an hour. The boxes in which the stone is carried are hung on to the rope at the loading end, the attachment consisting of a pendant of peculiar shape, which maintains the load in perfect equilibrium, and at the same time enables it to pass the supporting pulleys with ease. Each of these boxes carries 1 cwt. of stone, and the delivery is at the rate of about 200 boxes, or 10 tons, per hour for the three-mile distance. The proportions of such lines can be varied to any extent to suit the requirements of any particular trade, ranging from 10 tons to a 1,000 tons per day. In the case of lines for heavy traffic, where a series of loads, necessarily not less than 5 cwt. to 10 cwt. each, must be carried, a pair of stationary supporting ropes, with an endless running rope for the motive power, will be employed, but the method of supporting, and the peculiar advantage of crossing almost any nature of country with a goods line without much more engineering work than is necessary for fixing an electric telegraph, without bridges, without embankments, and without masonry, exists equally in both branches of the system. The cost of establishing these lines will vary considerably in proportion to the quantity they are required to carry, but from their peculiar construction their cost will vary very slightly in relation to the nature of the ground which they may traverse. The merit claimed by the inventor consists in the fact that he has entirely surmounted the difficulty heretofore felt in contriving means to enable the boxes in which goods are conveyed to pass along uninterruptedly to a great distance, in spite of curves and other disadvantages. The wire-rope employed is only half an inch in diameter, and this is kept in motion by an engine of 16-horse power, working at a pressure of 10lb. The rope, with the upright poles on which it is supported, has somewhat the appearance of a telegraphic wire; the great difference being, that in the one case the objects conveyed are *seen* in the course of their transit. Mr. Hodgson's present desire is to make his invention known in this country, in order that he may ultimately find favour with railway directors as a kind of auxiliary or accessory to the existing means of transporting goods; but his prevailing idea is that it will be found of more permanent utility in the colonies, and more particularly in those parts where experience has shown that it would not pay to construct a railway.

## THE ATMOSPHERIC TELEGRAPH.

A number of engineering and other gentlemen assembled a few weeks ago at the Waterloo Station of the South-Western line of railway, for the purpose of witnessing and testing the value of Messrs. Weir and Co.'s atmospheric telegraphic patents. At Clapham Junction a long train was in readiness, fitted up with Mr. Weir's apparatus, and the whole principle of the invention was made clear in a few minutes. It appears to meet all the requirements of the Government. By Mr. Weir's plan every carriage of a train of any length can be provided with the desired communication, and the carriages of that train can be disconnected easily and quickly without interfering with the communication more than a minute or two. Mr. Weir's invention is simply this—On top or bottom (whichever is most convenient) of each carriage is placed a metallic pliable-sided air-vessel. In connection with this air-vessel is a metal tube, which runs along the bottom of each carriage, and can be connected with other carriages in a somewhat similar but quicker way to that in which railway carriages are coupled. Nothing more is done than to point two ends of the tube that projects from the ends of each carriage and lock them securely together by some peculiar means. In each carriage is suspended what may be called an ordinary bell-rope handle, which the passenger has only to pull to call the attention both of the engine-driver and the guard. To deter passengers from using the bell-ropes unnecessarily, on the handle being pulled down it become locked, and cannot be replaced until the guard comes to the carriage in which it is placed. At the moment of pulling the bell-rope and giving alarm, a shutter is thrown out from the side of the carriage, which shows the guard the carriage in which his presence is needed.

## PATENT CASE.

### CRAIG *v.* M'FARLANE.

A case of interest to paper-makers has been decided by the Solicitor-General, Sir John Coleridge, at his chambers.

Mr. John M'Farlane, Leith-walk, Edinburgh, wire-cloth manufacturer, in the month of August last, applied for letters-patent for "Improvements in Rollers for Paper Making Machines," and obtained the usual provisional protection on application The application was opposed by Mr. Robert Craig, of Newbattle Mills, Dalkeith, on the ground that he was the first inventor of an under press roller, covered with vulcanite and vulcanised indiarubber, which formed part of Mr. M'Farlane's claim for a patent, for which Mr. Craig also applied and obtained the usual protection. Parties were heard in accordance with the practice of the patent office, in the absence of each other. Mr. Grove, Q.C., and Mr. Junner first appeared for Mr. Craig, and contended that he was the first inventor and applier of the roller which had worked satisfactorily at one of his mills; that Mr. M'Farlane, who had obtained the material for the covering of the rollers from the North British Rubber Company, simply acted as Mr. Craig's employé, and had not the merit of the invention; and that Mr. M'Farlane had only applied for his patent after the rollers had been experimented with by Mr. Craig, and been found a success. In answer to certain declarations filed by Mr. M'Farlane, in proof of his having experimented at a paper-mill at Wandsworth, in Surrey, counsel submitted that such experiments, assuming them to have been successful, had only reference to the under coutch-roll of the machine, and that Mr. M'Farlane, upon his own evidence, had not proved that he had ever experimented on the under press-roll, and was not entitled to the sealing of his patent.

Mr. Spence appeared for Mr. M'Farlane, and contended that he was entitled to the patent for the coutch and press rolls, and read certain declarations filed for Mr. M'Farlane. Mr. Craig's counsel having been called in, the Solicitor-General stated that he would cause Mr. M'Farlane's patent to be sealed for the coutch-roll alone, and would cause Mr. Craig's patent to be sealed for the press-roll, being all that was claimed by the latter in his specification.

## NEW METHOD OF DISCHARGING SHIPS OF GRAIN.

An ingenious and apparently practicable method of discharging vessels of grain has been devised by Messrs. J. and A. Hutcheson, engineers, Springfield-lane, Paisley-road. Hitherto this kind of work has been to a great extent manual, the only attempt at performing it means of machinery not having been very successful. The Messrs. Hutcheson's process is very simple. A screw revolving in an upright cylinder, the one end of which rests in the hold, brings the grain rapidly to the top through its thread, which is sufficiently deep to admit of the passage of a considerable quantity. Something of the sort, but working horizontally, is already well known under the term "creeper" in grain mills. An idea of the value of the process may be gathered from the circumstance that two 11in. cylinders, with screws of 3in. pitch, raised grain at the rate of 14 bushels per minute. By the application of such a power the cost of discharging grain ships would doubtless be very considerably lessened, while the delay caused by the present method would be obviated. Another feature of the invention is its adaptability to the purposes of the pump. With a greater rate of speed than is required for raising of grain, it will act with almost equal facility in the discharge of water, or grain and water mixed. We understand that the machine is receiving the attention of some of our leading shipowners, by whom, doubtless, its merits will be fully tested.

## THE "LION" SEWING MACHINE.

This is the latest and most perfect construction of lock-stitch sewing machine for general factory and family work, designed and constructed by the well known manufacturers, Messrs. Kimball and Morton. One of the new features of this machine is a new design of frame, the part above the sole plate being in the form of a lion *couchant* on a neat sole plate, embedded in the wooden table of the main standards and treadle frame, combining the lion and eagle, the arms of the two countries, where the sewing machine has been chiefly adopted. The working parts for actuating the shuttle below the sole plate are reduced to a simple reciprocating connecting rod, which actuates the carrier and driver of the shuttle and feeding lever, so that there is scarcely a possibility of anything going wrong with these few and simple parts, while the vertical and horizontal revolving spindles which communicate motion to the needle are enclosed within the body of the lion; the needle, and the needle-holder, working down through one fore leg and the presser foot down through the other, protected from dust or injury, and working with very little noise. The breast of the "lion" is removable by a single screw for tightening up the springs or joints when required; and the fore paws are removed or inserted according as the machine is at work or not. When not working these feet stop the motion of the needle-bar and mechanism, thus preventing the machine from being tampered with by the uninitiated, or the carelessness of parties putting their foot on the treadle. The machine, besides being fitted with all the most modern improvements for stitching, hemming, felling, braiding, binding, cording, frilling, and quilting, is fully as easily managed as any machine we have seen, working the slightest fabrics without puckering or drawing, and from the fewness of parts, as stated, is not liable to get out of order; thus combining all that could be desired in a sewing machine for general purposes, most creditable to the makers.

## STONE-DRESSING MACHINERY.

A number of master builders in Glasgow have erected machinery on the Pollokshaws-road, a little to the west of the Barrhead Railway Station, for the purpose of dressing or polishing stone. The machine consists of a circular iron table, on which the flags or rough stones are laid. This table revolves at great speed, and on the top of it an iron frame is placed, which can be raised to any height according to the thickness of the stones on the table. The top flags or stones are put loosely into the frame, face downwards, and are carried backwards and forwards by the action of the machinery while the bottom stones are revolving. Water and sharp sand are used, and in this manner great friction is produced, and the two faces of the stone are worked at the same time. On January 13th the machinery was started for the first time in presence of a number of gentlemen specially invited for the occasion. The revolving table was packed with rough building stones to the extent of about eighty square feet, and the upper frame was filled with paving stones as they came out of the quarry. The machine was set in motion, and worked admirably for a first trial. Water and rough sand were liberally applied and at the expiry of twenty-five minutes the engine was stopped for the purpose of testing the results of the experiment. It was found that the rough block on the iron table had been made smooth and level while the flag-stones on the top were as smooth as ice. In this manner, and in less than half an hour, one hundred and fifty feet of stone were polished into a building state, being an amount of work which eleven men could scarcely have accomplished in a whole day. Three of these machines have been erected on the site abovenamed, and they are likely to prove a great saving in labour.

## HTE SHEWELL BUOY.

In 1866, by Admiralty order, a fog bell-buoy was fitted at Portsmouth dockyard, on a plan submitted by a workman of the yard—a sawyer, named Shewell—to the Admiral-Superintendent, and has since then been placed at the extremity of the Spit Shoal at the extreme southern end of the entrance channel to Portsmouth harbour, as a test of its merits generally, and also of its efficiency as compared with that of the Peacock bell-buoy, which has for a number of years been the beacon at the "Spit." The "Shewell" buoy has stood all weathers for upwards of two years, and so satisfactory have been the official reports made to the Admiralty by the officials of Portsmouth dockyard, that orders have been issued for a second buoy to be fitted on the same principle and moored on the edge of the Spit to take the place of the one which has been on trial there, and which now requires repair. The superiority of the Shewell over the Peacock buoy appears to consist in the substitution of a continuous for an intermittent striking of the bell. The Peacock buoy has a flat head above the surface of the water, resembling the top of a small round table, and on this is built up the open lattice work, or cage, some six or seven feet high, which gives the buoy the necessary appearance to the eye from a distance as a warning beacon. This description will also suit exactly the construction of the Shewell buoy, the difference between the two buoys lying in the arrangement of their fog bells and strikers. With the Peacock buoy the bell is hung up under the crown of the highest part of the cage, and the striking of the bell is caused by the motion of the water giving the buoy sufficient oscillation to bring the ordinary clapper with which the bell is fitted with force against the side of the bell in proportion to the disturbance of the water where it is moored. It always requires considerable motion of the water to strike its bell, and at times when there is fog and little or no motion of the water, the bell gives out no warning sound; a delusion and a snare, under such conditions, to all mariners. The arrangement of the fog bell and its clappers on the Shewell buoy effectually disposes of this objectionable feature in a fog signal embodied in the arrangement of the Peacock buoy bell and its single clapper, a succession of rapid blows being kept up on the sides of the bell by the very slightest movement of the water where it may be moored. This is effected by hanging a bell without a clapper close down on the table-face of the buoy, where four metal balls move in as many covered grooves, equidistantly fixed round the outer circumference of the bell. There are thus four clappers in constant motion and striking against the bell, with the important advantage over a bell struck in the ordinary way, that the instant the blow has been struck the ball flies off from the side of the bell, and the latter gives a sound much more clear and distinct than it would by the old method of striking. The idea appears exceedingly good, although as yet not fully carried out.

## PROGRESS OF TASMANIA.

Mr. Nowell, the Government statist for this colony, has just issued his report for the year 1867. A review of the condition of the colony last year presents few encouraging features; in almost every direction the same law of decadence is found to have been in operation as in the preceding years The report is dated July 20, 1868, and Mr. Nowell states that since he. began to write his review there was more ground of encouragement as regards the future of Tasmania than had appeared for several years. The value of the imports in 1867 was £856,348, and that of the exports was £790,494, the former exceeding the latter by £65,854. Compared with the results of the preceding year, there was a decrease of £25,759 on the imports, and of £44,112 on the exports; indeed, the exports had not been so limited since 1851. Wool shows a decrease in the value exported of £6,423; the amount realised by exportation being £385,405 in 1866, and £378,977 in 1867. Bread-stuffs were nearly double the value of the exports of 1865-66; oats and barley show a decreasing value since 1857. The production of hops is rapidly increasing; in 1867, the exports were valued at £13,730, against a maximum in previous years of £6,695. The number of vessels which entered inwards was 598, and shows a decrease of 7 per cent.; the tonnage was 97,390, and shows a decrease of 9¾ per cent. as compared with the results of 1866. The number of vessels cleared outwards was 631, of 102,754 tons in the aggregate. The revenue in 1867 was £272,958, being an increase on that of 1866 of £27,531. Of the total revenue, £127,224 was derived from Customs' duties, and £56,087 from Inland Revenue; the receipts from the Customs were nearly the same as in 1864, and those from the Inland Revenue were about the same as in 1862. The expenditure last year was £255,552, or £13,191 more than in 1866. The revenue from the land fund was £124,945, against £88,343 in 1866; but the expenditure from this fund in 1867 amounted to £106,472. The actual debt of the colony was £1,017,900, or £10 6s. 11¾d. per head of population. The returns relating to gold mining show that the quantity of the precious metal obtained in the district of Fingal, as far as could be ascertained from the storekeepers or other purchasers of gold, was only 141oz., being the yield of the alluvial mines. The quartz companies realized 1,219oz. from 7,677 tons of crushed stone. The agricultural statistics return the entire area of the colony at 16,778,000 acres, of which 281,383 acres were under cultivation during the year ending the 31st of March, 1868. The acreage under crops of various kinds was 153,588, or 14,278 acres less than in 1866, the decrease being at the rate of 8·5 per cent. The acreage under each of the principal crops in the two years, 1866 and 1867 respectively, was as follows:—Wheat, 71,348 and 64,010; barley, 4596 and 6860; oats, 34,358 and 27,574; potatoes, 10,520 and 10,768; hay, 33,762 and 33,064. The culture of the sugar-beet is receiving some attention, and great interest has been taken in the cultivation of hops, the increase in the land under this crop being 93 acres, while the increase in the produce was 86,900lbs. The average yield of wheat in 1867 was 13.98 bushels per acre, against 21·43 in 1866; of barley, 24·40, against 26.28 in 1866; and of oats, 2·294, against 27·40 in 1866. The live-stock returns show a decrease in the number of horned cattle of 1772, an increase in sheep of 23,110, and an increase in pigs of 21,028. The estimated population of Tasmania at the end of 1867 was 98,455. The return of the aborigines in the establishment at Oyster Cove shows that one man and two women were the sole remains of the original possessors of this island. In a few years these few representatives of the race well have passed away, leaving scarcely a single monument, save some few articles preserved in the museums, and a few paintings, to tell that they had ever been. The immigration and emigration returns show an actual loss to the population of 466 souls. The deaths in 1867 numbered 1413, being in the proportion of 14·4 per 1000 of population. The births registered during the year were 2971, or 166 more than in 1866.

## REVIEWS AND NOTICES OF NEW BOOKS.

*Smoking Fires. Their Cause and Cure.*—By the Rev. ALEX. COLVIN AINSLIE. London: Lougman's, Green, and Co.

Mr. Ainslie's little work is another addition to the already numerous class of elementary treatises devoted to that branch of ventilation which is intended to provide against the nuisances due to smoking chimneys.

The treatise is readable, and may prove useful to non-professional people who have not previously considered the subject of ventilation, and beyond that class we do not suppose it is intended to pass.

In the preface, the author accuses science of having thought "the domestic chimney either beneath or above her notice." This remark exhibits that *crassia ignorantia* of the literature of the subject which should not appear upon the part of one who is writing thereupon. There are many works treating fully of the subject, and numerous patents have been obtained in connection with it.

Mr. Ainslie adverts to the remedies applied by tinmen as being hideous and useless, this is often true, but the person requiring assistance to obviate the smoke nuisance, should. we think, apply to some more erudite scientific authority than the average tinman.

The body of the work contains the causes of smoking chimneys, and their remedies, some very trite, thus page 67:

"75. Clause X.—A foul flue, which, as explained in Art. 31, is tantamount to a small flue." REMEDY.—Sweep it."

Taking the book altgether we can recommend it to the notice of householders, and such as may contemplate building houses.

*Sciography, or Radial Projection of Shadows.* By R. CAMPBELL PUCKETT, Ph. D., Head Master of the Bath School of Art. Chapman and Hall, 193, Piccadilly.

THIS treatise is intended for draughtsmen and students who have already become acquainted with the principle of perspective, but, as is too frequently the case, do not understand how to make their drawing effective by throwing shadows. Many, if not most, drawings in which shadows appear are very faulty in this respect, and not unfrequently the shadows are so badly thrown as to entirely spoil the effect of the whole sketch. The present work is designed to enable draughtsmen to avoid such anachronisms, and from the simple and lucid way in which the subject of shadows is treated, but a slight amount of study will be required to produce this most desirable result. One great merit of the case consists in the illustrated examples, which explain most distinctly the twenty lessons into which the author has most judiciously divided his treatise.

## CORRESPONDENCE.

*We cannot hold ourselves responsible for the opinions of our Correspondents.*

*To the Editor of* THE ARTIZAN.

DEAR SIR,—In your January number you state (at Notes and Novelties) that the firm Orlando, of Leghorn, launched the *Cappelini*. That government vessel is a new screw gun boat, three other such are building in Italy, and for all four we have furnished the machinery.

One set of those engines were at the Universal Paris Exposition, and were awarded a Silver Medal, and were very favourably noticed by English engineering publications, &c. We have built and repaired several steamers, screw and paddle, and are now building an auxiliary S.S. of 900 tons, and 100 horse-power, composite.—Yours, &c., WESTERMAN BROS.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

THE work on the artesian well at St. Louis which has been going down for so many years is approaching its close, and a few weeks will determine whether the undertaking is to prove a success or an expensive failure. The drills are now in what is called the pink sandstone, under which lies granite rock. Should the latter be reached without finding water, further attempts will be hopeless.

THE merchants of Bremen have resolved to fit out another Arctic expedition, and place it under the charge of Captain Koldewey, of the *Germania*. They are to furnish a steamer and defray expenses.

SEAWEED CHARCOAL is now used as a substitute for animal charcoal, it is said, with good results.

WORKING MEN'S INTERNATIONAL EXHIBITION.—The Hon. Anberon Herbert attended a meeting at the Queen's Hotel, Birmingham, on the 11th ult., and explained matters connected with the proposed exhibition to be held in 1870, as now arranged. He expressed a hope that manufacturers would give to their men facilities for becoming exhibitors by loans of materials, tools, or workshops for the manufacture of articles. A discussion followed, in which Mr. Elihu Burritt and others engaged. The following resolution was adopted:—"That, having heard the statement of the Hon. Auberon Herbert, this meeting is of opinion that the manufacturers and artisans of Birmingham should be solicited to co-operate in the proposed International Exhibition, to be held in London in 1870, and that a public meeting be called to lay the subject before the town, and that a provisional committee be appointed to make the necessary arrangements."

A GRND international exhibition of horticultural implements and also a botanical congress, will be opened at St. Petersburg in the month of May, under the patronage of the Czar.

### SHIPBUILDING.

THE following vessels were launched during the month of January, 1869:—The *Singapore*, a composite ship of 720 tons, built by Alex. Stephen and Sons, Kelvinhaugh, for T. H. Ismay and Co., Liverpool; for the San Francisco trade. The *Atlantie*, an iron barque of 540 tons, built by Alex. Stephen and Sons, Kelvinhaugh, for Mr. Tremellen, Swansea; for the Australian trade. The *Caroline*, an iron barque of 700 tons, built by Alex. Stephen and Sons, for Le Quellec and Bordes, Bordeaux; for the West Coast of South American trade. The *Ghazeepore*, an iron ship of 1,630 tons, built by John Reid and Co., Port-Glasgow, for M'Kinnon, Frew and Co., Liverpool; for the East Indian trade. The *Antilles*, an iron barque of 545 tons, built by Arch'd. M'Millan and Son, Dumbarton, for M'Arthur M'Lean and Co., Greenock; for the West Indian trade. The *Maria de C.*, an iron barque of 400 tons, built by Thomas Wingate and Co., Whiteinch, for Spanish owners. The ——, an iron screw steamer of 650 tons and 120 horse-power, built by Scott and Co., Greenock, for French owners; for the Mediterranean trade. The *Wiltshire*, an iron ship of 1,590 tons, built by Barclay, Curle and Co., Whiteinch, for George Marshall, London; for the East Indian trade. The *Urano*, an iron screw steamer of 1,700 tons and 300 horse-power, built by Wm. Denny and Brothers, Dnmbarton, for Austrian Lloyds' Steam Navigation Co., Trieste; for the Mediterranean trade. The *Roquelle*, an iron screw steamer of 1,300 tons and 250 horse-power, built by Randolph, Elder and Co., Govan, for the British and African Steam Navigation Co., Glasgow; for the Glasgow and West Coast of African trade. The *Asia*, an iron ship of 1,566 tons, built by Charles Connell and Co., Kelvinhaugh, for John H. Watt, Glasgow; for the East Indian trade. Total tonnage—11,341.

A STEAMBOAT ON GREAT SALT LAKE.—The *Kate Connor*, the first steamboat ever run on Great Salt Lake was successfully tried a short time ago. She is 50ft. long by 10ft. beam, has side wheels, and is owned by Gen. P. E. Connor, of Stockton, Cal., and was built by Mr. G. Hayward, of Salt Lake City. She is now engaged in hauling ties for the Central Pacific Railway.

### LAUNCHES.

MESSRS. Alexander Stephen and Sons lately launched from their works at Kelvinhaugh, the new iron sailing barque *Antonia*, of 700 tons, AA 1 at Lloyd's, and 20 years in Liverpool Registry. The *Antonia* is for French account, is sister ship to the *Caroline*, lately launched by Messrs Stephen, and is to be employed in the Valparaiso and West Coast trade. The ceremony of naming was performed by Miss Margaret Helen Alexander, of Claremont Terrace.

THERE was lately launched from the shipbuilding establishment of Messrs. Archibald M'Millan and Son, Dumbartou, a very handsome iron clipper barque, of about 600 tons burden, classed double A at Lloyds'. She has been built specially to carry a large cargo on a light draught of water, and is intended to trade from London to Cape Colony, and to go into such rivers as the Cowie. She has very superior accommodation for cabin passengers, is fitted with all the latest improvements, and is altogether a very highly finished and well got-up vessel, and is quite a credit to her builders. The launch was most successful; and as the vessel glided into her element she was named *Chiselhurst* by Miss Buchanan, daughter of Captain Buchanan, who has superintended the building and takes command of the vessel. She is built to the order of Mr. G. H. Payne, London, for his line. After the launch a select party of ladies and gentlemen adjourned to the moulding loft and partook of lunch, when the usual toasts were given and responded to.

MESSRS. Blackwood and Gordon, Port-Glasgow, lately launched from their building yard a handsome sailing vessel of 750 tons register, for Messrs Henry Whittle and Co., of Liverpool. This vessel is built for the San Francisco trade, and will be commanded by Captain Whittle, of Liverpool. On leaving the ways she was gracefully named the *Wood Hall* by Mrs. Whittle, wife of the commander. After the launch a large company met in the model room belonging to the yard, and partook of cake and wine. The usual toasts of success to the owners, builders, and captain, were proposed and responded to. The *Wood Hall* is the first sailing vessel built by Messrs. Blackwood and Gordon, and she is fitted with all the latest improvements in sailing vessels, having steam winches, fresh water condensers, patent pumps, and windlass wrought by steam. From her fine appearance in the water it is likely that this vessel will prove as great a success as the many fine steamers turned out by the above firm.

### STEAM SHIPPING.

CLYDE AND NEW YORK SHIPPING TRADE.—The returns of the shipping trade between the Clyde ports and New York during 1868 show a marked increase of prosperity over those of the preceding years, as regards outward and inward trade. Over 1867, which was an exceptionally prosperous year, there was an increase last year in the sailing from the Clyde of 3 vessels and 4,250 tons, but only an increase in the arrivals of 6 tons, the number of vessels being less by two than in the previous year. Over 1866, however, the increase in arrivals amounted to 18 vessels and 17,000 tons, and in sailings to 15 vessels and 16,600 tons; while over 1865 the increase in arrivals amounted to no less than 32 vessels and 42,000 tons, and in sailings to 42 vessels and 45,200 tons. The number of vessels which left the Clyde last year for New York was 73, and the tonnage 77,752, and the number which arrived 64, and the tonnage 72,058—a trade rather more than double that of four years ago. Besides this, an active trade has been carried on between the Clyde and other North American ports. Of arrivals there were six steamers and seven sailing ships of 7,015 tons from New Brunswick; 21 vessels, of 3,938 tons, from Newfoundland; 13 ships, of 5,418 tons, from Nova Scotia; 5 vessels, of 1,054 tons from Prince Edward Island: and 16 vessels, of 8,948 tons, from United States' ports other than New York. There sailed 34 vessels, of 5,963 tons, for Newfoundland; 10, of 6,446 tons, for St. John's, New Brunswick: 19, of 8,780 tons, for Nova Scotia; 10, of 4,373 tons, for Boston; and 25, of 17,378 tons, to other United States' ports.

"Countess of Erne."—This new paddle steamer, belonging to the London and North-Western Railway, made her trial trip on January 20th from Dublin to Holyhead, giving most satisfactory results as to her performance, making the run across at an average speed of fourteen knots an hour. The dimensions of the *Countess of Erne* are:—Length, 240ft.; beam, 29ft.; depth, 15ft. 9in.; tonnage, 996 tons; engines, oscillating, of 350 nominal horse-power, made by Fawcett, Preston, and Co., of Liverpool. The hull and boilers were constructed by Messrs. Walpole, Webb, and Bewley, Port of Dublin Shipyard, Dublin.

## TELEGRAPHIC ENGINEERING.

Brigham Young is said to have a telegraph wire leading to his office and connecting with every hamlet in Utah—a line of 500 miles long. Every settlement of half a dozen houses has a telegraph office with female Saint operators, and in charge of a Bishop of the Mormon church, who can report at any time all that takes place to Young. From his private office in Salt Lake City, like the watchman in the fire telegraph, Brigham may give an order or ring an alarm from Idaho to New Mexico.

American Telegraphs.—In the United States there are 4,126 telgraph offices, or one for every 7,549 of the population, and nearly every town and village has its office. Over 50,000 miles of line and 100,000 miles of wire, with 265 submarine cables, are in operation.

## RAILWAYS.

A Locomotive for use on common roads, made by M. Leroy, engineer, of Paris, was successfully tried a day or two back on the road from Havre to Montivilliers, a distance of about five miles, and through a hilly country. It made several trips, each time drawing a vehicle laden with passengers.

The Yorkshire Engine Company are engaged on a heavy locomotive order for Russia. The engines are of the long-boiler type.

The railroad between Port Huron and Detroit is likely to be conformed to the Canadian gauge, and it is possible that a line of the same gauge will soon be constructed across Michigan to Chicago, so that when the Intercolonial is opened, cars loaded in Chicago or Detroit can pass without transhipment to the sides of ocean vessels at Montreal, Quebec, Portland, St. John, or Halifax. New Brunswick is pushing on its railway extensions to the United States boundaries.

The Mont Cenis Tunnel.—The Italian papers states that the completion of the Mont Cenis Tunnel is to be celebrated by a great International Exhibition at Turin. The Government will ask Parliament to vote 3,000,000 francs towards the expenses; and the king has, it is stated, expressed himself favourably to the project. There are expectations of the tunnel being completed next year.

The Pennsylvania Railroad Company have contracted for twenty-four cars heated on a new principle. One of these has been constructed, and is a great improvement on those commonly in use. The stoves or heaters are placed underneath the car, and the heat is circulated by means of pipes and registers; thus the feet, which usually suffer the most with cold, are first protected. As these stoves would be readily detached from the car in case of accident, the plan adds much to the safety from conflagration. The cars are much more pleasing to the eye without the usual clumsy uncouth stove and coal box.

A new railroad is proposed to run from Pekin, Illinois, to Danville.

A line is about to be made between Lismore and Fermoy at the expense of the Duke of Devonshire.

A large reduction of fares on the London, Brighton, and South Coast Railway was announced on Friday at Brighton by a letter from Mr. Laing, the chairman, to the mayor. The reductions are comprehensive, and place the fares on the same basis as in 1863.

The managers of the Union Pacific Railway Company have announced that 1.000 miles of the line are now complete, and that adding to these the 500 miles constructed by the Californian Company, there only remain about 250 miles to make. This done, there will be direct railway communication between the Atlantic and the Pacific.

The Lancashire and Yorkshire Company have decided that £50,000 be authorised to be raised in connection with the expenditure on the Hull Docks, by the issue of new shares of £5 each, and entitled to the ordinary dividend of the company.

Considerable progress has been made in the widening of the North London line between Camden-road and Dalston, and arrangements are now in course of completion for letting the works at the stations. The branch to join the Tilbury Railway will, it is expected, be opened for traffic this month.

## MINES, METALLURGY, &c.

Iron ore has been discovered in Saugatuck, Connecticut, in a vein said to be very rich. The ore is of the same class as the Salisbury ore.

## WATER.

The Water Power of the Connecticut.—The town of Holyoke, Massachusetts, U.S. situated on the Connecticut river, has been created during the last ten years, and is now a flourishing seat of manufacturing industry, with between twenty and thirty large manufactories. The whole of the motive power is obtained from the Connecticut, which is dammed across, and pours over its whole volume with a width of 1,017ft. and a fall of from 25 to 30ft. The floods of last spring so far injured the dam as to render repairs amounting almost to reconstruction, necessary. These alterations are now being carried out, and consist in protecting the front of the dam for its whole length with a crib work having a sloping face, and filled with broken stone.

## APPLIED CHEMISTRY.

A Correspondent gives us an account of an ingeniously extemporized apparatus for removing carbonic acid from wells. It was simply an umbrella let down and rapidly hauled up a number of times in succession. The effect was to remove the gas in a few minutes from a well so foul as to instantly extinguish a candle previous to the use of the umbrella.

M. Sack has called attention to the fact that tungstate of baryta forms an excellent white paint, which has as good a tone and depth as white lead, and has the advantage above this of not getting blackened on exposure to the atmosphere. Zinc white, which was tried as a substitute for white lead, has failed through wanting body M. Elie de Beaumont remarks that if this statement was confirmed it would be of great importance for we have no need to employ special mining operations for tungsten, as this metal is commonly found in company with tin.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From £ | From s. | From d. | To £ | To s. | To d. |
|---|---|---|---|---|---|---|
| COPPER. | | | | | | |
| Best selected, per ton | 82 | 0 | 0 | 84 | 0 | 0 |
| Tough cake and tile do. | 80 | 0 | 0 | 82 | 0 | 0 |
| Sheathing and sheets do. | 83 | 0 | 0 | 84 | 0 | 0 |
| Bolts do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 85 | 0 | 0 | 88 | 0 | 0 |
| Old (exchange) do. | 69 | 10 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7¼ | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 7 | ,, | ,, | ,, |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 22 | 0 | 0 | ,, | ,, | ,, |
| Do. to arrive | 22 | 0 | 0 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 25 | 10 | 0 | 26 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 116 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 117 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 120 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 116 | 10 | 0 | ,, | ,, | ,, |
| Straits do. | 116 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 6 | 1 | 8 | 6 |
| IX. do. 1st quality do. | 1 | 12 | 6 | 1 | 14 | 6 |
| IC. do. 2nd quality do. | 1 | 5 | 6 | 1 | 6 | 6 |
| IX. do. 2nd quality do. | 1 | 11 | 6 | 1 | 12 | 6 |
| IC. Coke do. | 1 | 3 | 6 | 1 | 5 | 6 |
| IX. do. do | 1 | 9 | 6 | 1 | 11 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 12 | 6 | 6 | 15 | 6 |
| Do. to arrive do. | 6 | 10 | 0 | 6 | 12 | 0 |
| Nail rods do. | 7 | 0 | 0 | 7 | 2 | 6 |
| Stafford in London do. | 7 | 12 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 2 | 6 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 5 | 9 | 3 | 2 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 2 | 6 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 7 | 6 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 22 | 10 | 6 |
| Spanish do. | 18 | 5 | 0 | 18 | 7 | 0 |

*At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated January 19th, 1869.

167 S. G. Archibald—Machinery for cleaning boots, knives, &c.
168 M. Burke—Ships' skylights
169 G. Lowry—Hackling machines
170 W. Pain and J. Pain—Floor dog or flooring cramp
171 H. W. Hammond—Driving piles
172 J. Armstrong—Improvements in crossings and switch apparatus
173 C. Baunscheidt—Instrument for treatment of rheumatism, &c.
174 N. D. Spartall—Propelling vessels
175 W. R. Lake—Wheels for railway carriages, locomotives, &c.
176 C. E. Brooman—Breechloading guns.

### Dated January 20th, 1869.

177 G. A Crow—Drilling machines
178 J. Siddeley and F. N. Mackay—Ice making
179 F. A. Paget—Steam boilers, &c.
180 W. Gillett and C. Bland—Bell and clock chimes
181 J. Edwards—Communication between passengers and guards of railway trains, and signalling, &c.
182 E. Burton—Distributing sand &c. in public thoroughfares
183 E. Barcroft—Cocks, taps, &c.
184 P. C. Evans—Feeding wool &c. to carding machines
185 M. J. Matthews—Harmoniums
186 H. A Bonneville—Illuminating gas
187 H. A. Bonneville—Metallic action frames for pianofortes
188 F. Lipscombe—Purifying water
189 C. de Bergue and C. Faure—Improvements in locomotives, &c.
190 D. Spooner—Construction of mills for cleaning rice, &c.

### Dated January 21st, 1869.

191 J. W. Wilson—Steam boilers
192 J. C L. Camel—Surgical truss
193 D. Rivenc—Apparatus for mending and cutting millstones
194 A. M. Clark—Scarf fastenings, &c.
195 C. J. Chubb—Coal drills
196 T. C. Lewis—Steam engines
197 C. G. Gumpel—Escutcheons
198 F. Walton—Artificial marble
199 W. R. Lake—Apparatus for shearing animals and skins

### Dated January 22nd, 1869.

200 R. Baxenden and J. Heald—Looms
201 A. B. Cunningham—Apparatus for throwing horses
202 B. Craig—Communicating and signalling between guards, passengers, and drivers of railway trains
203 M. Tildesley—Annealing cans
204 J. Wilkins—Manufacture of looped and knitted fabrics
205 J. Speight, J. E. Barton, and E. Brooke—Twisting wool
206 A. Maw—Moulds for china, &c.
207 F. R Ensor—Lace
208 T. Cook and J. Watson—Measuring gas, &c.
209 J. W. Horsfield and J. W. Horsfield—Steam boilers
210 W. E. Gedge—Slate cutting machines
211 W. Dennis—Letter boxes, &c.
212 W. Burgess—Mincing machines
213 J. Beattie—Railway buffers

### Dated January 23d, 1869.

214 J. Millward—Quarrying machines
215 J. Ortton—Graduating the admission of steam to engines
216 E. Simons—Communicating between passengers guard, and engine driver
217 W. Huggins—Dressing millstones
218 L. J. Crossley and R. Hanson—Steaming printed yarns
219 H. H Murdoch—Smelting copper
220 B. Mountain, T. Richmond, and G. Duffield—Boot and shoe manufacture
221 J. Dinsdale—Spinning and twisting machinery

### Dated January 25th, 1869.

222 J. M. Merrick—Composition for the manufacture of various useful or ornamental articles
223—W. M. Welling—Compositions resembling ivory
224 C. Touchevieux—Hinges of earrings
225 C. P. Parkinson, A. Metcalfe, J. Metcalfe, and W. H. Heald—Mules for spinning
226 R. G. Lowndes and M. M. Callam—Apparatus for finishing textile and other fabrics
227 C. E. Brooman—Cocks and valves
228 W. E. Newman—Stamping sheet metal
229 J. Carr—Tapes for venetian blinds
230 A. V. Newton—Fermenting substances and germinating grain
231 E. Hartley—Looms
232 H. D Bowyer—Wheaten flour
233 R. J. Green—Collar studs, &c.
234 J. Roberts and S. Roberts—Moulds for casting
235 H. W. Lafferty and R. Lafferty—Centrifugal machines for draining sugars, &c.

### Dated January 26th, 1869.

236 C. L. Wood and J. Stockley—Grinding plate glass
237 E. D. Ruston and W. W. Mills—Window sashes
238 J. D. Ellis—Rolling armour plates
239 J. Wilson, J. Wilson, and G Cryer—Preparing wool, &c.
240 J. Millar—Envelopes
241 J. Wilson—Shaking straw
242 J. Pickering—Treating timber
243 W. R. Lake—Ventilating apparatus
244 A. V. Newton—Cutting Veneers
245 H. Law—Connecting metal pipes
246 C. Gil—Manufacture of sugar

### Dated January 27th, 1869.

247 C. French—Intercommunication on railway trains
248 C. Mather—Singeing fabrics by gas flames
249 T. Reeder—Sheet metal rollers
250 J. Gough—Applying ink or colour to printing surfaces
251 J. Taylor—Propelling ships
252 T. Vaughan and J. W. Smith—Treating smoke and soot for the preparation of an article of commerce therefrom
253 H. Barcroft—Damasks, &c.
254 J. Porteous and H. Gibson—Manufacture of tobacco
255 T. Brown—Liquid discharging apparatus for extinguishing fires
256 J. H. Johnson—Keys or wedges for the permanent way of railways
257 E. Girdwood—Envelopes and bags for transmitting samples
258 E. H. Prentice—Phosphatic manures
259 J. Silman—Knives for cutting out the soles of boots and shoes
260 G. Taugye—Letter copying presses
261 C. Langley—Caissons and pontoons for lifts, &c.
262 A. C. Pass—Condensing and purifying metallic and other fumes, &c.
263 C. W. Petersen—Improvements in life-boats, steam tugs, &c.

### Dated January 28th, 1869.

264 R. M. Marchant—Obtaining power for locomotive and stationary purposes
265 W. Spurrier—Salt spoons. &c.
266 W. Brown and T. H. Garbutt—Fire-bars
267 R. Jones—Curing or preserving animal substances
268 C. D Abel—Apparatus for washing, wincing, fulling, and finishing textile fabrics
269 C. L. A. Hoelscher—Musical chair
270 R. Blackbee—Improved pessary
271 A. Browne—Rotatory engine
272 L. P, Hebert and L A. Moulin—Press for stamping letters, books, &c with ink or other colouring matter
273 J. Cox—Destroying burrs, &c. in wool in a raw state

### Dated January 29th, 1869.

274 J. Easterbrook, J. H. Ailcard, and A. M. Wild—Grinding and polishing engine slide bars, shear blades, &c.
275 N. C. Szerelmey—Tarpauling
276 G. Hawksley—Ventilators and chimney pots
277 W. MacLean—Improvements in printing machinery
278 J. Pickering—Propulsion of ships, vessels, and boats
279 T. W. Carter—Construction of ships
280 J. McDonald—Stoppers for bottles, &c.
281 S Smith—Taps or valves for regulating the flow of steam. &c.
282 G. Hawksley—Pumps
283 G. Price—Window fastenings
284 J. H. Johnson—Piles, faggots, or billets of iron or steel
285 A. M. Clark—Machinery for hulling or decorticating grain
286 A. Mallard—Horse-shoes
287 F. Jay—Oil paint

### Dated January 30th, 1869

288 T. E. Lundy and T. Hood—Driving sewing machines by electro magnetism
289 T Whimster—Exhausting, washing and forcing gaseous bodies
290 P J. Wielemans—Ovens
291 W. Weldon—Regeneration of certain compounds of manganese from certain residues
292 T. Pimbley—Alarm communication between railway passengers, guard, and engine driver
293 S. Taylor and G. W. Dyson—Spade and shovel moulds
294 H. N. Nissen—Printing bankers' checques and similar documents
295 K. C. Watson—Boots
296 E. T. Hughes—File-planing machine
297 E. T. Hughes—File-cutting machine
298 R. Wood—Improvements in steam engines
299 J. Tolson—Cleaning the cards of carding machines, &c.
300 G. H. Adam—Apparatus to enable the driver of a locomotive engine to ascertain the condition of the train
301 T. H. Kilner—Feed apparatus to carding and condensing machinery
302 A. S. Andrews—Horse collars

### Dated February 1st, 1869.

303 J. T. Bintley—Billiard and bagatelle tables
304 J. Whyte—Tailors' shears and scissors
305 C. D Abel—Apparatus for casting ingots
306 T. G. Daw—Forming stereotype matrices
307 J. A. Limbert—Apparatus for moving heavy bodies, &c.
308 A V. Newton—Improvements in machinery for condensing slivers
309 J. A. A. Fontaine—Hydrostatic hoist

### Dated February 2nd, 1869.

310 R. Caunce, M. G. Bradley, and B. Bradley—Apparatus for twisting yarns, &c.
311 C. Hoult—Screens or shields for covering fire-place openings
312 A. Barclay—Ejector condensers
313 J. Proud—Basket cars
314 N Voice—Apparatus for regulating the flow of water, &c.
315 D. Joy—Apparatus for extracting oils
316 S. Brooke—Condenser carding engines
317 A. E. Harris—Artificial teeth
318 W. I Palmer and W. P. Goulding—Evaporating and calcining alkaline solutions
319 W. A. Smith—Preservation of meat, &c.
320 J. Bird—Kilns or ovens for drying and burning bricks, &c.
321 W. E Newton—Construction of the permanent way of railroads
322 H. Bate—Improved top
323 W. Brabazon—Improved iron chain net for oyster dredges

### Dated February 3rd, 1869.

324 V. Baker—Improvements in vessels for containing hot liquids
325 J. Slater—Railway carriages
326 J. G. Willans—Manufacture of iron and steel
327 J. Mackintosh—Ornamenting surfaces
328 J. H. Tyrrell—Measuring liquids
329 A. S. Stocker and A. R. Stocker—Infants' feeding bottles
330 C. D. Abel—Hydraulic cement
331 F. Vanderaey—Bricks, &c.
332 C. E. Brooman—Stays
333 W. Lister—Filtering syrups
334 W. Maddick—Internal fire tubes of boilers
335 R R. Frohock—Improved machines for making lasts
336 J. E. Johnson—Photographic pictures
337 L. Wray—Carbonizing wrought iron
338 A. V. Newton—Sewing machinery
339 J. Howard—Turn-wrest ploughs

### Dated February 4th, 1869.

340 H. Bryceson, J. Bryceson, and T. H. Morten—Application of electricity to organs
341 T. Parkinson—Doors for regulating the admission of air to furnaces
342 J. J. Bagshawe and W. F. Batho—Manufacturing semolina and flour
343 E. d'Artois—Inkstand
344 T. Pankhurst and T. Pankhurst—Gully traps
345 E. Lord—Furnaces for steam boilers
346 P. Jensen—Utilizing the motion of waves
347 R W. Knowles and G. Green—Stretching and finishing muslins, &c.
348 J. Vavasseur—Working heavy guns or ordnance
349 E. Morewood—Tin plates
350 G. Bray—Slip hook
351 W. E. Newton—Elevated railways
352 H. Jones—Sounding tuning forks

### Dated February 5th, 1869.

353 G. Ashworth and E. Ashworth—Manufacturing paper fasteners
354 J. Jobson—Explosive projectiles
355 F. Braby—Utilization of the waste solution of sulphate of iron
356 W. Blundell—Chimney guards
357 J. Page—Pipe joints
358 J. Henderson—Surface condensers
359 W. Adams and W. G. Beattie—Bearing springs
360 J. Taylor—Machinery for raising and lowering bodies
361 J. H. Johnson—Mounting and working ordnance
362 J. Halford—Puddling furnaces
363 A. Clark—Mules for spinning yarns
364 A. Browne—Manufacture of stearine
365 D. D Kyle—Communicating and signalling in railway trains
366 C. G. Hill—Rosettes and trimmings

### Dated February 6th 1869.

367 C. S. Dawson—Elastic stamp for printing on paper, &c.
368 H. A. Dufrene—Manufacture of ice
369 J. S. Offord—Clipping horses
370 W. R. Lake—Puddling furnaces
371 R. Snook—Cocks, taps, and valves
372 J. C. Shaw—Apparatus for cutting wire, rods of metal, &c.
373 J. T. Edmonds—Apparatus for giving medicine to horses
374 H. A. Bonneville—Compound for preparing jelly broth
375 C. D. J. Seitz—Furnaces and pans for the recovery of soda from waste lyes
376 E. Meldrum—Paraffine oil
377 T Harrison—Seed drills
378 B. Walker and W. Tilson—Jacquards and reading machines

### Dated February 8th, 1869.

379 E. W. Hawes—Buoys
380 T. Nicols and J. Parr—Signal bells
381 L. Strauss and A. Seckbach—Preserving and improving beer
382 E. J. D. Fossard—Clyster pump
383 R. W. Row—Solitaires, links, &c.
384 J. H Johnson—Steam engine Governors
385 O Sarony—Photographs
386 W. R. Lake—Lining for furnaces
387 W. R. Lake—Knitting machines
388 B Hunt—Vacuum gauge
389 H. J. Richman—Fans
390 F. Jenkin—Electric light

### Dated February 9th, 1869.

391 W. A. Lyttle—Magneto-electric apparatus
392 R. Phelps, G. Phelps, C. W. Phelps—Feeding bottles
393 G. Rees—Designs on glass
394 W. Williams—Communicating between passengers and the guard and driver of railway trains
395 J. Dennell and G. W. Dennell—Cutting soles and heels for boots
396 J. Wilkinson and W. Scott—Looms
397 G. White—Automotor
398 W. Mitchell—Felt carpeting
399 L. A. C. St. Paul de Sincay—Metallic tiles for roofing
400 G. Critchley and H. B. Fox—Rocking chairs
401 G. F. G. Desvignes—Boilers
402 B. F. Sturtevant—Furnace blower
403 J. H. Johnson—Heating apparatus
404 J. H. Johnson—Paper making
405 E. J. A Camere—Rotary steam engines

### Dated February 10th, 1869.

406 K. B. Edwards—Communicating between passengers and the driver and guard of railway trains
407 G. Gros—Self closing boxes
408 W. Hilton—Looms
409 J. Crofts—Combing wool
410 J. Stuart—Separation of wool from vegetable fibres
411 S. Mellor—Pumps
412 W. Lever—Hats
413 S. W. Mulloney—Surgical bandage
414 C. T. E. Lascelles—Casks
415 F. J. Knewstub—Locks
416 J. F Bentley—Filters
417 W H. Fischer—Photographic printing
418 G Broadhurst and J. Kershaw—Double texture cloth
419 P. Tayseu—Stearic acid
420 J Clayton—Paste for fixing and brightening colours
421 J. Greenfield—Hopscotch cloths
422 J. A. F. Suter and T. C. Hinde—Heating steam boilers
423 J. Carter—Waterclosets
424 J. E. Billups, W. Cooper, G. T. A. Hine, and W. Young—Communication between passengers, guards and drivers of trains
425 W. R. Lake—Water velocipede

### Dated Febeuary 11th, 1869.

426 G. F. Ansell—Steel and iron
427 P. J. Smith, F. W. Smith, H. G. Smith, and A. Pappenberger—Pianofortes
428 G. A. Nowell—Lamps
429 J. Young—Measuring the pressure of gasses
430 H. P. Hansen—Stoves
431 C. Thomas—Reaping machines
432 B. P. Stockman—Water meters
433 A. C. Engert—Mouldings

### Dated February 12th, 1869.

434 H. Edwards—Preserved food
435 W J. Horton—Railway chairs
436 T. A. Collinson—Buttoned boots
437 F. J. Vandenvinne—Plough
438 W. H. Hayhurst—Looms
439 H. B. Binko—Indigo, carmine, &c.
440 T. V. Trew—Screw propellers
441 G. H Morgan—Carriages
442 W E Newton—Explosive compounds
443 A. V. Newton—Rotary engine
444 F. C. Hills—Furnaces of gas retorts
445 W. Summers—Packing cases for storing mineral waters

### Dated February 13th, 1869.

446 C. Gordon—Breechloading firearms
447 A. W. Taylor—Method of ceiling walking
448 J. Holmes—Sash holder
449 W. E. Newton—Heating apparatus
450 D. Hanton—Ploughs
451 E. G. Brewer—Constructing metallic joints
452 S. W. Campain—Seed and manure drills
453 W. Basford—Bricks and tiles

### Dated February 15th, 1869.

454 W. Haycock and W. Carter—Horseshoes
455 B. Hunt—Saws
456 A. Morton—Improvements in the induction of fluids
457 W. H. Taylor—Combined harness buckle and loop
458 W. R. Lake—Mechanism for changing shuttles in looms
459 E. J. Hill and R. Davis—Signaling apparatus
460 A. H Lewis—Extracting copper
461 T. Hattersley—Spindles
462 C. W. Lancaster—Wadding for breachloading cartridges

### Dated February 16th, 1869.

463 S. Shaw—Lacing and buttoning boots and shoes
464 T. Bond—Construction of casks
465 T. Winder—Spring coupling
466 H. Posen—Fastening for purses, &c.
467 T. Billyeald—Hair nets
468 W Smartt—Utilizing heat
469 L N. Legrus—Preservation of animal and other substances
470 V. A. Houdaille—Metallic bungs
471 G. W. R. Pigott—Consecutive manufacture of various articles from materials capable of being formed by tension, compression, or extension thereof
472 B. J. B. Mills—Brickmaking machinery
473 C. E. Brooman—Treating waste of wool, silk, horn, &c.
474 H. Tylor—Spring bedsteads
475 A. McNeile and J. Slater—Carriage wheels
476 J. Fletcher—Begass furnaces
477 F. Walton—Artificial leather
478 H. Mulliner—Hanging broughams
479 J. W. Yates—Spades, shovels, &c.

### Dated February 17th, 1869.

480 T. Sugar and Thomas Richmond—Looms
481 J. Wood, B. Wood, and R. Wood—Steam engines
482 E. T. Hughes—Washing machines
483 J. Atkins—Metallic beds ends
484 E. Roond—Vessels for holding and cooling or warming fluids or solids

# SEA-GOING TURRET SHIPS

BY

ADMIRAL PARIS

Trace N° 1

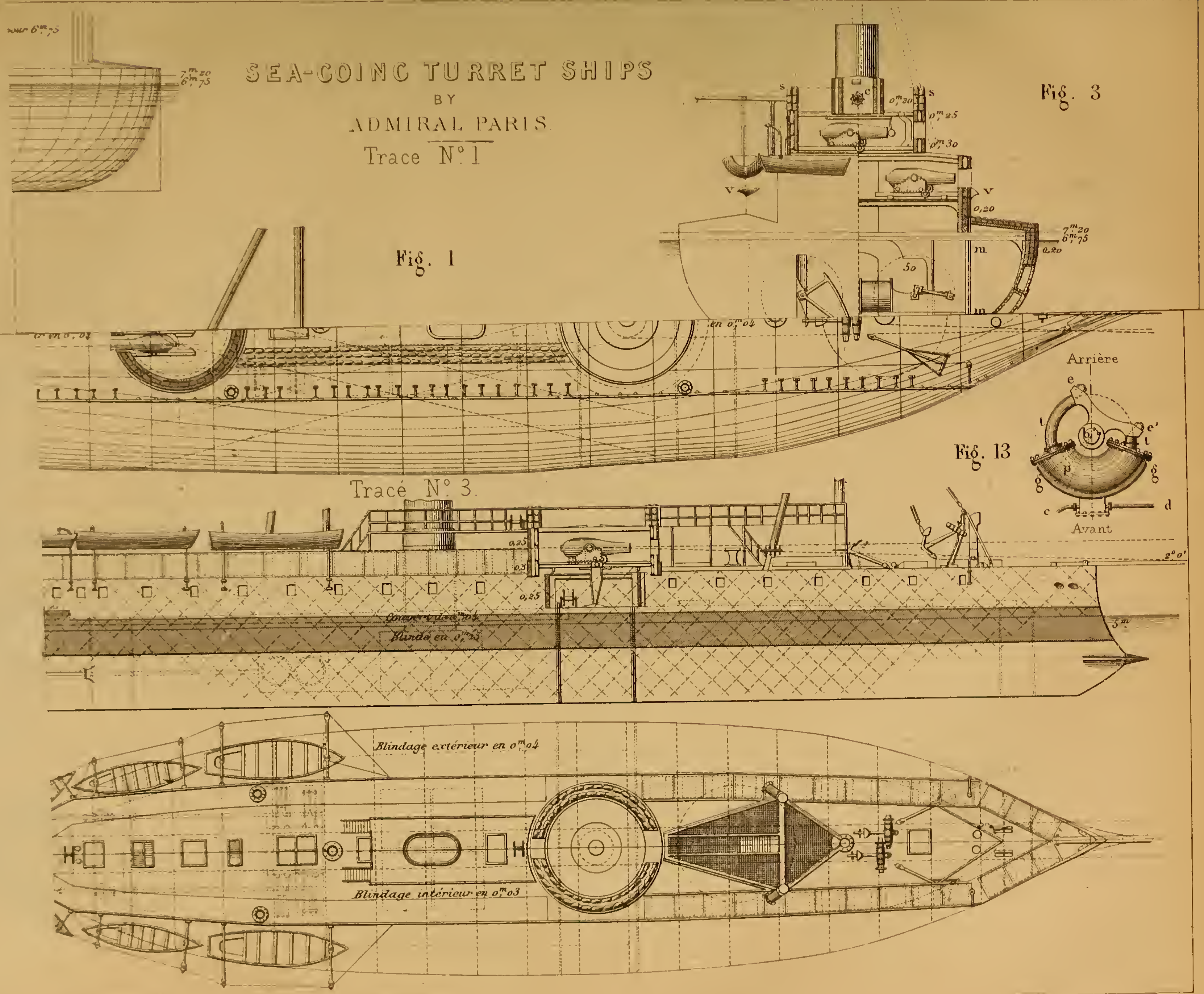


Fig. 1

Fig. 3

Fig. 13

Tracé N° 3.

# SEA-GOING TURRET SHIPS

BY

ADMIRAL PARIS

Tracé N° 1

Fig. 4

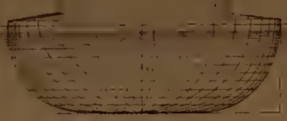


Fig. 3

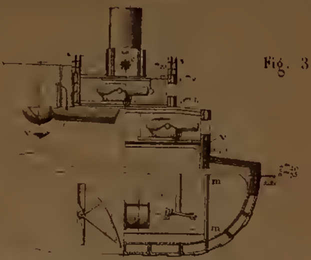


Fig. 1

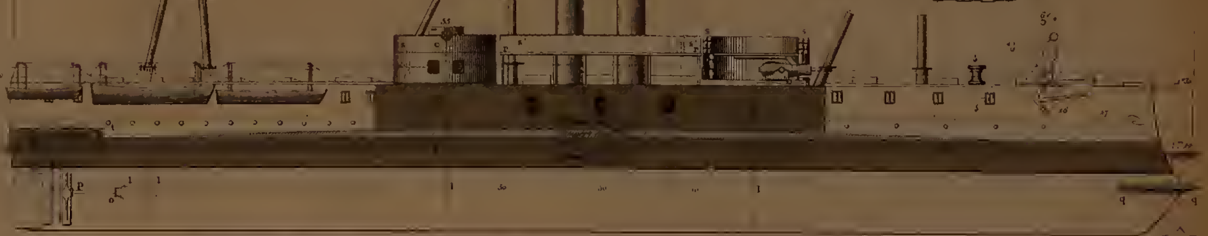
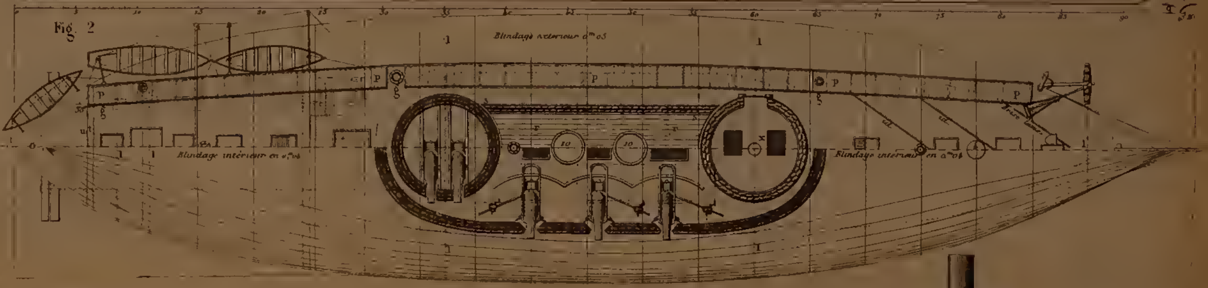


Fig. 2



Tracé N° 2

Fig. 8

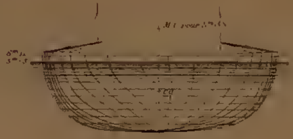


Fig. 7

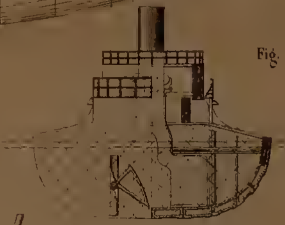


Fig. 5

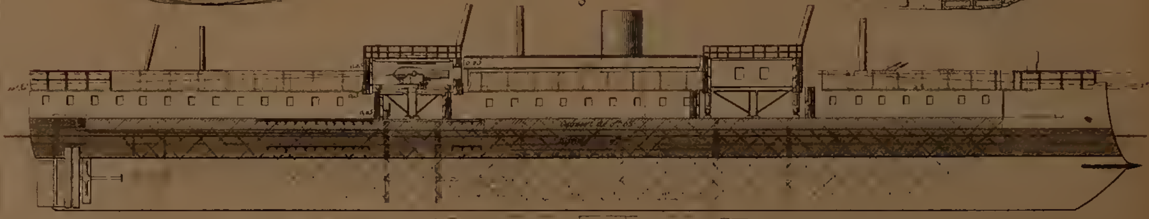


Fig. 6

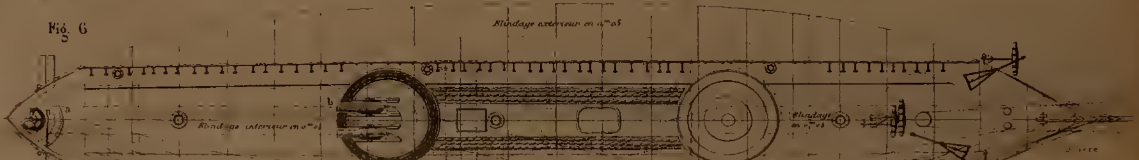
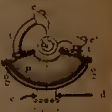


Fig. 13



Tracé N° 3

Fig. 11

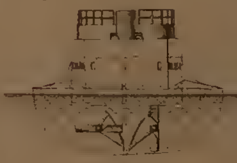


Fig. 9

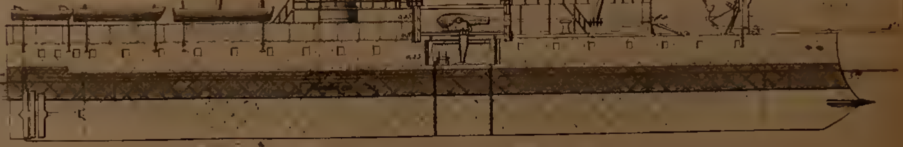


Fig. 12

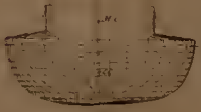
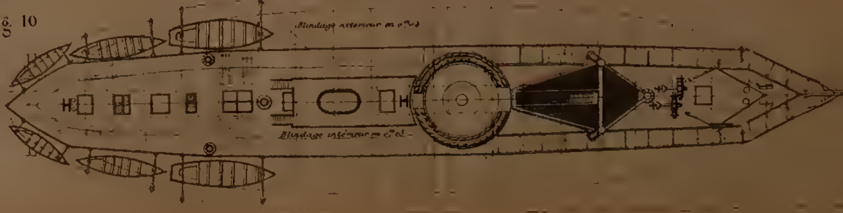


Fig. 10



# THE ARTIZAN.

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## SEA-GOING TURRET SHIPS.

By Admiral Paris.

(*Illustrated by Plate* 343).

The subject of sea-going turret vessels, which is one of such vast importance to this country, has just now acquired still greater interest from the fact lately disclosed by Mr. Childers, the present chief of the Admiralty, that our government have at last determined to entirely leave off building wall-sided iron-clads, and construct only turret ships. It will be remembered by the readers of The Artizan that the superiority of turret ships have been constantly pointed out, as for instance when illustrating the Monitor *Dictator* in October 1867, also when giving the lines of the *Bellerophon* in September 1868 and at various other times, and it cannot be otherwise than gratifying to find that the views there expressed have at last, in spite of most strenuous opposition in high places, been adopted by the Admiralty.

Few, if any authorities upon this subject stand so deservedly high as Admiral Paris—whose paper before the Institution of Naval Architects last year attracted so much attention—or who has devoted so many years to the study of its merits, and we have therefore given in the accompanying Plate (343) several illustrations, together with the following explanation of his views as communicated by him.

Since the first appearance of the *Gloire* as a sea-going iron-clad, but few changes have arisen in the general features and form of vessels of this type. The only alteration of a notable character consists in the adoption of a central battery, which system has been rendered necessary, because, by reason of the increasing penetrative power of shot, it has been found practically impossible to carry armour of sufficient thickness over the whole length of wall-sided ships to afford them ample protection. One consequence of the introduction of central batteries, has been a reduction in the number of guns carried by a vessel; thus ships of the magnitude of the *Bellerophon* and *Hercules* now carry only four or five guns on each side.

It is evident, however, that these guns will be more effectively used in a turret than in a central battery, and this is now beyond dispute, the doubts militating against the turret system having been cleared away by the trials of monitors in active warfare, and by their sea voyages. Also as all iron-clads have been built of the same shape, that is to say, with vertical sides and rounded bottom, they commonly roll heavily, shipping water through their ports and over their bulwarks and preventing the use of those guns which in the old ships of war would have probably been brought into action: to this defect must be added the danger arising from the rolling of the vessel which tends to expose the weak or un-armoured parts of the vessel every few seconds. Hence at the present time it appears that in the ordinary system of wall-sided iron-clads, the limited range of guns, the low height of their elevation above the surface of the water and the rolling of the ships are defects gravely impairing their other qualifications which have been so greatly enhanced by the skill of many of our modern engineers.

There appeared, however, on the other side of the Atlantic, a peculiar description of vessel, which was only designed for navigating rivers, but was found to possess a remarkable stability in a sea way, only rolling about one-third as much as vessels of the ordinary build. The natural conclusion from this almost unexpected result is, let us adopt similar shaped vessels; or, in other words, let us build monitors. But if this form were adopted throughout the entire navy of any country, she would be unable to carry on a war in open sea in bad weather, as it is acknowledged to be unsuitable for a heavy sea. The problem therefore is, how to obtain the advantages of stability and extensive range of fire as possessed by the American monitors, in vessels capable of navigating the ocean in all weathers. This problem Admiral Paris endeavoured to solve, after having had the advantage of studying the various models in the Paris Exposition, and having reliable information respecting the monitors, together with long experience at sea. To design a vessel which should be as free from rolling as a monitor; as seaworthy, and with as good accommodation, as vessels of the usual form, and carrying her guns a sufficient height out of the water, with an all round fire, was his object.

As regards stability, or freedom from rolling, it is well known that a boat-hook floating in the water, and kept right by the weight of the iron end, is least affected by the waves. Again, a plank weighted on the bottom side will not roll, while a body in the form of a sphere, or a cylinder, has no stability of its own, and requires a large amount of ballast to keep it upright. The contrast between the motion of different shapes of buoys in a heavy sea, is a simple illustration of varying stability. A body of almost equal specific gravity to, and which consequently has its upper side level with, the water, such as a boat filled with water, or a piece of ice, moves with the waves, but only so far. The first of these forms would, of course, be impossible, as the vessel would be impracticably deep, besides which, a complete immobility is undesirable. The merits of the circular form are about to be proved by the Winan's yacht, and presents many difficulties; while the monitors have proved, on a large scale, the influence of waves upon a body of a specific gravity nearly equal to water.

These three illustrations, applied to the usual construction of vessel, which may be described as a semi-cylinder, with a parallelopipedon over it, show that it is the form of maximum rolling, especially if weight is fixed outside to add to the inertia. It is well known that a raft rolls less than a boat, while a boat hook, floating close to them, is quite motionless, for which reason it has been employed as a wave tracer for showing the rolling of ships and the motion of waves, and has been found to act very perfectly. It is, moreover, necessary to rely upon the well established fact of the non-rolling of the monitors, as the excessive motion of iron-clad vessels have fully proved our ignorance of the laws which govern the motion of ships, because if any theory upon this point really existed, it would be unpardonable not to have applied it.

For this reason, when it was first proposed to construct iron-clad vessels, Admiral Paris proposed that a model should be built—say about 130ft. long

—with iron frames and wood planking fastened with screw bolts, thus making a composite vessel. With such a vessel experiments might have been tried with weights in every possible position, and after having experimented sufficiently, the boat might be hauled ashore, the planks removed, and the frames put in the furnace and afterwards bent, so as to form a vessel of some different shape upon which to try similar experiments. By these means a considerable amount of practical knowledge could have been obtained as to the best form of vessel for war purposes. May it be hoped that at some not remote period a society, such as one of those which are so justly celebrated in England, will make these questions practically *à l'ordre du jour*, and institute a series of public experiments.

It has been already mentioned, the monitor is the best form of vessel for stability, and is also perfectly adapted to the smooth surface of rivers, where the ship's company have frequent opportunities to breathe pure air ashore, though they cannot be considered as adapted for long voyages at sea. The first monitor was sunk in weather which permitted another ship to use her boats; while the *Weehawkee* and the *Affondatore* suffered the same fate, in consequence of opening the hatches to breathe a little air after a battle. The voyages of the *Miantonomoh* and the *Monadnock* do not prove the seaworthiness of those vessels any more than the successful trip of the *Red, White, and Blue* proves that a row boat is a safe craft in which to navigate the ocean.

The point therefore is to attain as near as possible to the non-rolling quality of the monitors, and avoid their unseaworthiness which the Admiral endeavoured to accomplish in the following manner. It will be seen on Plate (343) that the midship section of the proposed vessels are formed of parts of circles for the sides with a flat bottom, the sides rising but a short distance above the water line, and covered with a deck for a certain distance inwards; when the sides again rise to a sufficient height to admit of ports being placed well above water, this portion being long and narrow somewhat similar to a river steamer in shape. Upon reference to the cross sections shown in the Plate (343) it will at once be observed that with the exception of the comparatively narrow raised portion, the vessel is similar in section to a monitor, and consequently possesses the similar properties of stability. This element being the most important point, it was necessary to study it carefully and therefore the writer calculated the positions of centre of *carène** and the metacentre both when the vessel was upright and also when heeled over at various angles up to 20° from which the following table was obtained.

| Inclination. | Draught to lowest point of immersion. | Displacement of *carène* P. | Distance of centre of *carène*. To water line. | Distance of centre of *carène*. To longitudinal plan. | Height of metacentre over centre of *carène*. | Height of centre of gravity to water line. + over — under. | Height of cr. of grav. over cr. of *carène*. a. | Value of $\rho - a$. | Moment of Stability. M. | Momentum of sails. M′. | Value of $\frac{M}{M'}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | m. | Tons | m. | m. | m. | | | m. | | | |
| Vessel upright | 6·750 | 8368 | 2·875 | 0·0 | 5·85 | —0·58 | 2·30 | 3·55 | 29716 | 72766 | 0·408 |
| Inclined 5°... | 6·765 | „ | 2·90 | 0·42 | 4·05 | —0·60 | 2·31 | 1·74 | 14560 | | 0·209 |
| „ 10°... | 6·795 | „ | 2·95 | 0·73 | 3·40 | — 0·62 | 2·335 | 1·065 | 8912 | | 0·106 |
| „ 15°... | 6·840 | „ | 3·03 | 1·02 | 3·30 | — 0·65 | 2·375 | 0·925 | 7740 | | 0·092 |
| „ 20°... | 6·92 | „ | 3·12 | 1·29 | 3·48 | — 0·70 | 3·415 | 1·085 | 9079 | | 0·107 |

Vessels of this form are notable clippers but for the sake of comparison we will take a spread of canvas equal to that of an old three decker with 3,000 square mètres, the centre of effort being 26·20m. above the water line. The Admiral then compared the moment of stability at various inclinations with that of vessels built upon the old system and given in a table in a most instructive work by M. Fréminville sub-director of the school of Genie Maritime entitled *Guide du Marine* which is as follows:—

| Names of Ships. | Value of $\frac{M}{M'}$ for the ships indicated. | Ratio of the stability of the proposed Ship (*Tracé* No. 1), to that of each of the vessels named below for inclinations of Normal. | 5 deg. | 10 deg. | 15 deg. | 20 deg. |
|---|---|---|---|---|---|---|
| | | Times. | Times. | Times. | Times. | Times. |
| *Breslaw*, 100 guns, with full complement ...................... | 0·082 | 5 | 2·55 | 1·29 | 1·12 | 1·30 |
| Stores having been used...... | 0·059 | 6·9 | 3·54 | 1·8 | 1·55 | 1·84 |
| *Tage*, 90 guns, with full complement.......................... | 0·096 | 4·25 | 2·37 | 1·11 | 0·95 | 1·12 |
| Stores having been used...... | 0·078 | 5·1 | 2·69 | 1·36 | 1·18 | 1·37 |
| *Breslaw*, with full complement | 0·076 | 5·37 | 2·75 | 1·40 | 1·21 | 1·41 |
| *Alceste*, 52 guns, with full complement .................. | 0·067 | 6·09 | 3·12 | 1·58 | 1·37 | 1·60 |
| Stores having been used...... | 0·053 | 7·59 | 3·94 | 2·00 | 1·73 | 2·00 |
| *Jeanne d'Arc*, 44 guns, with full complement ............... | 0·063 | 6·47 | 3·31 | 1·68 | 1·46 | 1·70 |
| Stores having been used...... | 0·051 | 8.00 | 4·10 | 2·08 | 1·80 | 2·10 |
| *Eurydice*, 30 guns, with full complement ...................... | 0·077 | 5·30 | 2·71 | 1·37 | 1·195 | 1·39 |
| *Obligado*, 10 guns, with full complement ...................... | 0·065 | 6·27 | 3·21 | 1·63 | 1·41 | 1·64 |
| Stores having been used...... | 0·059 | 6·91 | 3·37 | 1·80 | 1·56 | 1·88 |

From these figures it will be seen that the stability of the proposed ship No. 1, which has been calculated for a light cargo, or at least for a mean one, is eight times that of some of the old ships after the stores were used, and if compared with the *Tage* with full compliment of stores and provisions, the ratio is 4.25 times, the position of No. 1 being normal. But it is to be observed that at 5 degs. the ship No. 1 has 5 per cent. less stability compared with the *Tage* with full compliment, but 1.18 more after the stores have been used. With regard to the other ships the stability is higher even when their stores are on board. It has also to be remarked that though the stability is a minimum at the angle of 15 degs., it rises afterwards, and at 20 degs. is much higher.

Admiral Paris is aware that the comparison with the ships mentioned is not so fair as would be one with old ships having "tumbling home" sides, such as the *Royal Louis*, &c., designed by M. Ollivier in 1750, and such as that proposed by the Admiral formerly. These have a *carène* like other ships that is to say, 88 m. long, 18.20 m. beam, and 8 m. draught, but the upper deck would not be proportionately so wide as the more modern vessels, so that the metacentre would be motionless, as in the old class of ships, as shown in the work entitled "L'Art Naval à l'Exposition de 1867." The plan first proposed, and here alluded to, was but a first step towards the present arrangement.

It should here be observed that all the calculations relating to the present proprsed form of turret ships have been made in reference to the largest shown at *Tracé* No. 1, Pl. 343, and proportionately reduced for the two others, of which the lines and proportions are relatively the same.

It may be of advantage to those engaged in the examination of such questions as that under present consideration to be made acquainted with the method pursued in the calculations to economise time and labour.

The calculation of the centre of *carène* for a ship when inclined is exceedingly tedious, wherefore the writer employed a term called the *mean section*, which is obtained by taking the arithmetical mean of the ordinates to each water line and setting off the height as obtained in this manner. Then is the centre of *carène* situate in the centre of this figure, as may be proved by arithmetically calculating a centre of *carène* according to Stirling's differential method, as employed by the Swedish Constructor Chapman, the French Naval Architect Clairbois, and now adopted by naval architects generally. The writer draws attention to this method, as he found it exceedingly difficult to make the necessary calculations within reasonable time in the ordinary manner.

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* That portion of a vessel which is below the water line, when floating in any position whether upright or inclined.

To return, however, to the more important question of stability, which was treated by Mr. E. J. Reed, C.B., in a very interesting paper "On the Stability of Monitors under Canvass," read by him before the Institution of Naval Architects at their meeting held last year; he states that monitor-like ships, such as the *Duncan*, possess but little stability when upright; which decreases rapidly as the vessel heels over and the deck becomes immersed. Mr. Reed endeavoured to illustrate his position by means of diagrams, showing a spread of sails as wide as before this vessel was converted. But this *rasé'd* vessel is far from being similar in midship section to the common monitors, which, having very flat bottoms, have a vastly superior stability. A flat ship carries its metacentre very high; as an illustration may be mentioned the outrigged canoes of Point de Galle, well known to eastern travellers, and which are capable of carrying the largest sails in the world in proportion to their size. It would, of course, be very uncomfortable to sail in a vessel which, according to Mr. Reed, would capsize if inclined more than about 5 degs.; but on reference to Plate 343 it will be seen that when, owing to a press of sail, the vessels there shown heeled over to any considerable extent, the proper stability would be restored as soon as the water reached the inner side of the ship; besides which the angle between the deck and the inner side there shown might be filled up by curving the deck upwards as it approaches the inner side.

(*To be continued.*)

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## PATENT ANCHORS.

### By Francis Campin, C.E.

The importance of being able to obtain ship's anchors upon which perfect reliance may be placed can scarcely be overrated, and to offer reasons for such an opinion would be merely a work of supererogation, as they are patent to everyone who gives the subject even the most cursory consideration.

For a very long period there prevailed a certain carelessness in the matter of the construction and capabilities of anchors on the part of mariners and shipowners, the result of which was that few or no attempts of a really earnest nature were made to improve upon the simple form of the common anchor and produce something that should approach more nearly to being a guarantee of safety in such cases of emergency as those in which the vessel's preservation or destruction depends upon whether it is firmly held to its anchorage or not.

Amongst the earliest improvements in anchors may be noticed those by Trotman and by Porter, the latter making one step in advance of the former. By means of these inventions, greater security was offered, but not to such an extent as would satisfy the exigencies of the case. The improvement in Trotman's anchor consists in hinging the arms carrying the flukes or palms instead of making them rigid, as in the ordinary anchor, but the peculiarities of the different descriptions of anchors will be better understood from the accompanying illustrations than from mere verbal description.

Fig. 1 represents the common form of anchor, A being a front and B a side elevation. The letters in both views apply to the same parts: *a* is the shank, *b* the stock, *c* the shackle for the cable, *d* the crown, and *ee* the flukes or palms of the anchor.

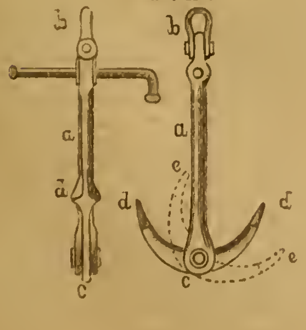


FIG. 2.

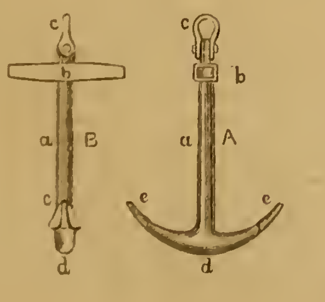


FIG. 1.

It will be observed that this anchor is rigid—that is to say that the stock, shank, and palms are immoveable in respect to each other, and, to all intents and purposes, solid.

The principal desiderata in an anchor are as follows: It should quickly and easily take the ground when dropped; if the ground be rotten where the anchor is dropped, so that it breaks away, it should immediately take hold again; it should be easily "tripped," "fished," and "catted," when required; it should not be liable from its form to fouling by cables, &c.; it should be of such shape as to do the least possible damage to the bottom of any vessel which might happen to strike on it; and, finally, it should possess the greatest possible strength with a minimum amount of material.

It is evident that in the anchor illustrated above there exist many grave defects. A very great cross strain is brought upon that portion of the palm of the anchor which is adjacent to the shank, and the fluke which is *not* embedded is very liable to be fouled, and also very dangerous to any vessel which might ground on it, and this is a point of some importance, as sunk anchors are sometimes left in anchorages where at low tide such an occurrence is not unlikely. Again, as to hold, only one palm or fluke is in action at a time. Some time back, Admiral Hall introduced an anchor which was merely of the common description split into two, longitudinally. The object of this arrangement was to allow of one anchor doing duty for two, it being supposed that one half of the anchor would do as well as the *acting part* of a complete anchor, without regard being had to the fact that in dropping such an anchor it would be necessary to send a boat out with it to make sure of its one fluke being towards the ground. Moreover, if it were to break away, or "come home," it might very likely turn over and drag for miles, without the slightest chance of taking hold again; there is also the great fault of weakness at the root. These defects are so evidently inimical to the success of the invention that it would be superfluous further to comment upon it.

Fig. 2 represents Trotman's patent anchor; *a* is the shank, *b* the stock, *c* a pin passing through the head of the shank, and carrying the flukes or palms, *d d*. In this arrangement, instead of the flukes being rigidly fixed in position in respect to the shank, they admit of very considerable motion about the pin *c*, being able to assume the extreme position shown by the dotted line *e e*. In this mode of construction, some of the grave defects of the old form of anchor are to a considerable extent mitigated, although not obviated entirely. By means of the motion of the flukes they are enabled to assume such a position that (*e*) the acting fluke takes a much deeper and firmer hold than it does in the case of the common anchor, and the inactive fluke being brought down upon the shank of the anchor it does not offer so dangerous an impediment to a vessel passing over it at low tide. The pin *c* may to some extent be regarded as a weak point in this anchor, but if proportioned properly I do not think there is much danger to be apprehended from this source. It is desirable not to overlook one danger, which is that of dragging. If the anchor happens to drop with that fluke which is *close to the shank* downwards it is evident there will not be much chance of the palm taking hold; this defect, however, is in some measure remedied in Porter's improvement upon Trotman's anchor.

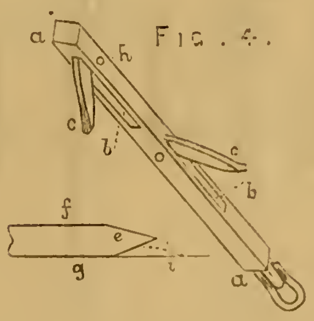


FIG. 4.

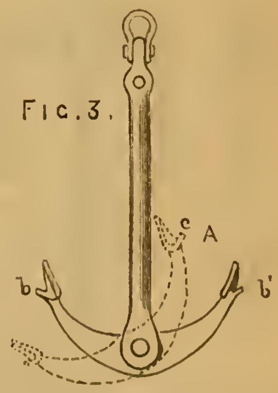


FIG. 3.

Porters' anchor is shown in fig. 3. It will be observed immediately that its general configuration and principle of working is almost identical with that of Trotman's, but the improvement consists in the addition of the continuations or counter-flukes *b b'*, formed on the backs of the flukes The object of these counter flukes is to ensure the anchors taking the ground when dropped. It is evident, for instance, that if the anchor be on the ground when the flukes are in the position shown by the dotted lines, and in such manner that the fluke A rests upon the ground, as the anchor begins to drag, the counter-fluke *c* will take hold, and bring the fluke into the position shown at *b′*. There may be one objection to this counter-fluke to be found in the fact that to some extent it tends to impede the progress of the main fluke in penetrating the ground. In other respects the remarks I have made upon Trotman's anchor apply with equal force to Porter's.

In both the foregoing anchors, although I have stated that the mode of construction enables the acting fluke to take a deeper and better hold than is the case with the common anchor, this may not always be so, but the patent anchors may be made to take a hold as good and deep as that of the common description with a much smaller span or distance between the flukes.

A form of anchor has been recently re-introduced which is perhaps scarcely worth notice, but for the fact that it has been set forth as a novelty, which, however, it may be, on the other side of the Atlantic, whence I believe it is imported. This anchor is shown in fig. 4.

This contrivance comprises a long square shank *a a* attached to the ship's cable by the shackle *d*. Through this shank are formed two slots *b b* at right angles as shown. Within the slots are suspended on pins two separate flukes or palms *c c*, which may swing out on either side of the shank, according to which one is downwards. This is about the worst description of anchor that has ever yet been introduced, and its defects are so glaring that it is astonishing such a design should ever have been suffered to come under public observation.

In the first place, if the shank be lying on level or tolerably level ground there is but like chance of the fluke taking hold on account of its peculiar form shown at *f*. It is clear that the part *g* would rest on the ground and slide or drag along it, until some chance obstacle lying in its path arrests its progress by contact with the point *e*. The point *e* cannot be curved downwards, as shown by the dotted lines *i*, so as to more readily take the ground, because the fluke is required to act equally well in both directions—that is to say, which ever side is downwards. Supposing, however, that the point *e* does take the ground, the shank of the anchor rises somewhat, and in all probability (there being no stock to steady it) immediately afterwards falls over again, leaving the fluke free to drag, unless indeed the second fluke at right angles to the first should happen to take hold before the shank has fallen far enough over to relieve the first fluke; but even when both palms are in the ground a very slight lateral movement must materially weaken their hold.

Lastly may be noticed a defect which alone would render this anchor eminently unsafe, which consists in the enormous strains to which the pins *h h*, carrying the flukes are exposed. It is obvious that any force acting at the end of one fluke is greatly magnified when brought on, by the great leverage afforded by this mode of construction.

Passing now from anchors which hold with but one fluke at a time, and which may therefore be considered as only giving half the useful effect required from them we came to a more promising class, viz.—those anchors which take hold of the ground with both flukes simultaneously.

The first anchor of this class to which I shall direct attention is that invented by Snell, it is illustrated in Fig. 5.

FIG. 6.

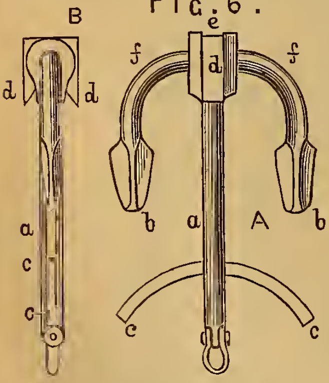
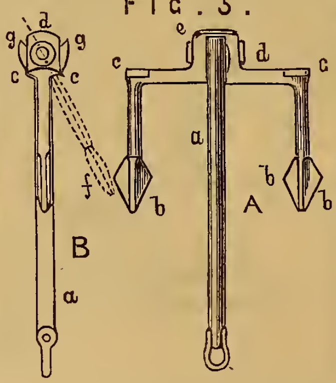


FIG. 5.



*a* is the shank, *b b* are the palms, both of which are brought simultaneously into action whichever side of the anchor falls downwards; these palms are carried by a cross-piece, *c c*, which is doubly cranked in the centre of its length as shown at *e*, in view A, so as to admit the head of the shank *a*, which is secured by the pin *d* in such a manner that the palms can oscillate to one side or the other of the shank, as shown by the dotted lines at *f* in view B. The distance through which the flukes can oscillate is determined by the stops *g g* on the head of the shanks, one of which comes in contact with and arrests the motion of the portion *e* of the cranked piece *c c*. At each of the extremities *c c*, there are two counter-flukes as shown more clearly in the side elevation B, which are attached in order to ensure the flukes taking the ground as soon as the anchor is dropped.

In this anchor the great improvement consists in bringing the two flukes simultaneously into operation and with certainty, for so soon as the anchor touches the ground the counter-flukes *c* take hold and bring down the palms *b b* into a suitable position for penetrating the ground. At first sight it may be imagined that there would be some difficulty in "tripping" this anchor, but practically such is not the case.

In regard to the faults of Snell's anchor, I may mention that the weak point is in the cranked part *e* and the pin *d*, and also that there is some slight liability to foul in counter-flukes, although not in a very great degree. No stock is added, as the counter-flukes on the transverse part *c c* serve to steady the anchor.

The form of anchor represented in Fig. 6, in which A is a front and B a side elevation is one which has many points which would seem to claim for it the position of the best anchor that has yet been tried, and it certainly has undergone some exceedingly severe tests; it is the invention of C. Martin.

*a* is the shank of the anchor, *b b* are the palms, which act simultaneously in taking the ground; *d d* represent the "sectors," or counter-flukes, which ensure the main palms falling into the proper position for penetrating the ground when dropped; *e* is the head of the shank, which is enlarged to allow of the passage of the portion between the flukes, which oscillates in the aperture through the head of the shank; for convenience I shall call this part the "journal" of anchor. In the centre of the journal is firmly fixed the double sector or pair of counter-flukes, *d d* one of which taking the ground causes the main palms to take, the other, or upper counter-fluke, at the same time coming down upon the shank of the anchor, and thus limiting the motion of oscillation of the main palms. *c c* is the stock which is made of a segmental or curved form, in order to reduce the danger of fouling to a minimum.

In this arrangement the "journal" presents great advantages over the pin in the last, being much stronger, and obviating the necessity for cranking the part between the palms or flukes, also by using the double sector, *d*, only two instead of four counter-flukes are required, and they cannot foul, as the one exposed must be in contact with the shank of the anchor. The round shoulders also, *f f*, are preferable to the square, both for strength and clearing any cable. Care is required to be paid to the manufacture of the "sector," as it is upon that the greater portion of the strain is brought to bear, but no difficulty has arisen in this matter.

It may be mentioned that ships moored to these anchors have ridden safely through storms, where others, not so fitted, have been speedily driven from their anchorage.

In concluding these remarks, I would notice that it may appear to some that the question of the qualifications of anchors comes properly within the province of those following the nautical profession, and, undoubtedly, they alone can determine by experience which anchor is really the best, of course presuming that the matter is investigated in a fair, impartial manner; but some of these experiments may prove somewhat dangerous where anchors may be under trial which prove unequal to their work. On the other hand, wherever a question is raised involving different modes of construction, or mechanical arrangements and the *strength of parts*, the engineer is the proper authority, and can speak *ex cathedrâ*, and in this spirit I have written the present paper.

## RAILWAY ECONOMY.

In commencing this article it is proper to say that it has been suggested by the perusal of Mr. Imray's pamphlet on "British Railways as they are and as they might be," of which a brief notice will be found amongst our "Reviews and Notices of New Books."

The incidents of the past few months—or, we might say, of the past few years—have drawn public attention very pointedly to the management and mismanagement of the railways of the United Kingdom, and at the present time a most decided general interest is felt in the subject and manifested in ways which show beyond a doubt that the travelling public have determined to rescue themselves, or rather their pockets, from the tyranny exercised for some time past over them by railway boards and financiers. This has been evidenced by the resolute resistance which has been offered to the raising of the fares on certain of the metropolitan and suburban lines of railway, which has shown itself in the promotion of street tramways, and in the running of special omnibuses, &c. Certain of the boards of directors for some time past seem to have acted in a very culpable manner, forgetting apparently the gravity of the interests with which they have been entrusted, and the spirit in which a Railway Act is passed by Parliament, which aims at the good of society at large, and only advisedly sacrifices for a time the convenience of a very small portion of the community for the benefit of the great mass, when it is necessary to cause any inconvenience, which, however, is not the case in the majority of instances.

Hence the Boards of Directors have two apparently distinct interests to protect—those of the shareholders and those of the public at large, or of such portion of that body as consists of habitual travellers. Although it may not at first sight appear self-evident, yet it is a fact that the course of procedure most beneficial to the interests of the shareholders is also that which is best suited to the convenience of the travelling public; hence, in oppressing the latter, the railway officials have materially injured their own constituencies, simply by pursuing a plan which could result in nothing but failure ultimately.

This plan has consisted in lavishing the funds of contiguous lines in maintaining an internecine competition of such magnitude as to shake the most prosperous companies; in ruinous parliamentary expenses, incurred in the support of certain acts applied for and in opposing others; and, lastly, in raising the fares so as to discourage travellers from using the railways. We need search for no more striking instance of the futility of such irrational competition than that which was shown in the conduct of the London Chatham and Dover Railway and the South Eastern Railway, between which the contest was maintained until the former could not escape ruin, and the latter was proportionately damaged, when an amalgamation was arranged between the two companies as regarded the fares to stations in towns through which both lines pass. Had this arrangement been made at the beginning, the shareholders would have been benefitted considerably, and we do not see that the public generally would have lost, at all events not permanently.

Not only is the raising of the railway fares objectionable *per se* as requiring an increased outlay on the part of the travellers, but it also gives rise to a feeling of distrust, for, by taking such a step, the railway companies have been morally guilty of a breach of faith towards the poorer class of society, as may be thus briefly shown.

A few years back amongst other advantages proposed to be derived from the establishment of local lines, much was said about the benefit that would accrue to the working classes, from the carriage to and fro being so cheap, that those working in large and close cities like London, would be able to reside a little way out in the country, and come up daily to their work, and moreover, the fares by railway were supposed to be met by the low rate of house rents in certain suburban districts. Under these circumstances there would not be much opposition to the removal of premises occupied by certain of the working classes, as the tenants imagined that they would ultimately be enabled by the arrangement to live in more healthy localities without incurring any considerable increase of expenses. This however was not to be, for no sooner do the railways get established and those living in the suburbs settled comfortably down than, first because of the convenience afforded by the train for easy access to London, the house rents rise, and next the railway companies having settled their mutual disagreements, combine to raise their fares! Thus perhaps the rate for travelling is raised above the means of the workman, and he is placed beyond such a distance as he might walk. Hence he must again seek a home in the close neighbourhood he had been tempted to quit, or trust himself within the domain of some less exorbitant line of railway.

Mr. Imray advocates the adoption of a system of cheap and uniform fares, and argues very reasonably that increased dividends would result from such an arrangement. He proposes that all tickets should be issued by Government, and suggests the use of tickets each of which shall entitle the owner to travel a given number of miles, (say 25,) on any part of any railway in the United Kingdom, the prices of the tickets being:—

| | 1st. | 2nd. | 3rd. |
|---|---|---|---|
| Square tickets for 25 miles and under ........................... | 1s. | 6d. | 3d. |
| Oblong „ over 25 miles ........................................ | 16s. | 8s. | 4s. |

Luggage tickets 1s. each.

Under these rates anyone might of course travel, for instance, forty-eight miles by means of two square tickets, and so on for longer distances.

The tickets are proposed to be issued and sold by government, their value, less duty, being repaid to the companies presenting them at the Inland Revenue Office. Such a system would be exceedingly simple and convenient for travellers, and would save much delay in taking tickets at railway stations, besides affording a check against fraud on the part of the railway servants.

From the figures given by Mr. Imray it would appear that on the adoption of his suggestions there would ensue an increase of about £2,000,000 per annum in passenger fares or about 14 per cent. on the present returns.

Probably, however, the most satisfactory course that could be pursued would consist in transferring the management of railways to a government board; the first point then to be considered would be the mode of compensating the railway proprietors. Mr. Imray suggests that the properties should be valued by the profit they are actually paying, whether as dividends, interest on mortgages, debentures, or otherwise, and that every one receiving dividends or interest from railway property such an amount of 3 per cent. government stock as would produce an annual equivalent to what he now receives. Thus nominally the National Debt would be increased by some 1,500 millions sterling, and the national expenditure by about 20 millions. For the additional debt, however, there would be the security of the kingdom. and to meet the increased expenditure there would be the annual railway receipts, which without doubt would be greatly increased by the improved system of management.

Considerable economy would also ensue from the centralisation of the ruling authorities, for the whole system could be managed by one government board, whereas at the present time there are nearly 500 railway boards in the United Kingdom. Again, all the rolling stock becoming one property, each line would not, as now, require always to have sufficient stock to meet the greatest emergencies, as at times a portion of the Northern stock might be used on the southern sections of the general system, and *vice versa*.

Although Mr. Imray's propositions require much consideration to mature them into a thoroughly workable form, we think that they possess great merit, and point out the direction which should be followed in undertaking the amelioration of our vast railway system. That some decisive measure must ere long be adopted is beyond a doubt; for the present state of affairs—directors blamed, shareholders dissatisfied, and the public disgusted—cannot last long, and we shall certainly welcome the first movement which may hold out hopes of future improvement.

## OUR SHIPS OF WAR.

In his speech in moving the first of the Navy Estimates, on the 8th ult., Mr. Childers made a very interesting statement with regard to our naval strength. He said:—First as to ironclads not yet completed. At Woolwich, the *Repulse*, launched, but which will not be ready for sea till July; at Chatham, the *Monarch*, which will be ready for sea in May, and the *Sultan* and the *Station*, which will be three-fourths complete at the end of the financial year, and ready for sea about July, 1870; at Pembroke, the *Iron Duke*, which will be launched in winter, and will be completed in May, 1870. The ships building by contract are: in the yard of Laird Brothers, the *Captain*, turret, which ought to be ready in April, but will not, I fear, be ready till July; in Napier's yard, the *Audacious*, which ought to be ready in July, and the *Invincible*, which ought to be ready in October; in the yard of Laird Brothers, the *Vanguard*, which ought to be ready in October; in Palmer's yard, the *Swiftsure* and the *Triumph*, both of which will be half finished this financial year; and in Napier's yard, the *Hotspur*, which will be all but finished this year. The unarmoured ships are these:—At Woolwich, the *Thalia*, corvette troopship, which will leave Woolwich in September to be fitted at Sheerness; the *Druid*, corvette, which will be ready in July, and the *Spartan*, corvette, which will be ready in April. At Sheerness we have the *Briton*, corvette; at Portsmouth, the *Dido*, corvette; and at Devonport, the *Tenedos*, corvette,—all of which will be completed in the course of the present financial year. At Pembroke we have the Inconstant, frigate, which will be completed in May next. In addition to these ships we have two small gun vessels, which will be ready in a short period. We have building by contract only two large corvettes, the *Active* and the *Volage*, which are being built by the Thames Company, and which will be ready for sea in June or July. The result will be that at the end of the financial year 1869-70 the only unfinished ships will be, at Chatham, the *Sultan* and the *Glatton*, which will require three months to complete; and at Pembroke, the *Iron Duke*, which will require one month to complete. The ships building by contract—namely, the *Triumph* and the *Swiftsure*—will require nine months, and the *Hotspur* one month to complete. There will be no unarmoured ships in hand at the end of the financial year, except a small gun vessel at Chatham. I will now proceed to give them the particulars of the new ships we are about to lay down in the dockyards. The two vessels of which I am speaking will be turret ships, each of 4,400 tons and of 800 nominal horses' power, but really of 5,600 horses' power. They will have double screws and four engines, and their speed will be 12½ knots per hour. Their construction will enable them to carry 1750 tons of coal—a quantity sufficient to last for 12 days' consumption at a speed of 10 knots. They will carry four 25-ton guns, while their freeboard will be 4ft. 6in. The base of the turrets will be protected by a raised breastwork, of oval form, 7ft. high. Their armour will consist of plates 12in. and 10in. thick on the sides and breastworks, and of 14in. on the turrets, while the backing will be from 12in. to 20in. thick, having an inner skin of armour 1½in. to 1¼in. behind. Their deck armour will consist of 2in. and 2½in. plates. They will have no masts, and therefore their turrets will have an all-round fire. Their crews will consist of 250 men and officers, and the cost of each will be £286,000, including their engines. Their draught will be between 25ft. and 26ft., I believe. We propose to build, thirdly, at Portsmouth, a turret ram, a sort of improved Hotspur. The difference between the proposed vessel and the Hotspur will be that the former will be somewhat larger, will have thicker armour, and will have a revolving instead of a fixed turret. The new vessel will be of 3200 tons burthen, of 700 horses' power, working up to 4200, of a speed of 12 knots, and will carry 350 tons of coal, sufficient for three and a half days' steaming at 10 knots per hour. It will carry two 18-ton guns in one turret, its freeboard will be 1ft. 6in., and it will have a 7ft. breastwork round its turret. Its armour plates will be of the following thickness:—9in. and 11in. on sides, 12in. on breastwork, 12in. and 14in. on turret, and 2in. on deck. It will carry a straight fore and aft rig without shrouds, and its cost will be £195,000, including the engines. The only other ship we propose to build in the dockyards will be one or two small vessels, like the Staunch, either at Portsmouth or at Devonport. We shall have altogether 36 broadside vessels, carrying 555 guns, and these vessels I have classed in a way that I think will be intelligible to the House.

The first class includes two vessels, the *Hercules* and the *Sultan*, protected by 6in. to 14in. armour, of a speed of 14½ knots per hour, and carrying 18-ton 10in. guns and under, their engines being nominally of 1,000 h.p. Class 2 consists of six vessels—namely, the *Audacious*, the *Invincible*, the *Vanguard*, the *Iron Duke*, the *Swiftsure*, and the *Triumph*. These vessels are protected by 8in. to 16in. armour, possess a speed of 13½ knots per hour, and carry 12ton 9in. guns and under. Class 3 consists of nine vessels—namely, the *Bellerophon*, the *Lord Warden*, the *Lord Clyde*, the *Minotaur*, the *Agincourt*, the *Northumberland*, the *Royal Alfred*, the *Repulse*, and the *Penelope*. These vessels are protected by 5½in. to 6in. armour, possess a speed of 13 to 14 knots per hour, and carry 12 ton guns and under. Class 4 contains eight vessels—namely, the *Achilles*, the *Royal Oak*, the *Prince Consort*, the *Caledonia*, the *Ocean*, the *Valiant*, the *Hector* (the two last badly protected), and the *Zealous*. These vessel are protected by 4½in. armour, have a speed of 12½ knots per hour, carry 9ton 8in. guns and under, while their engines are of 1,000 h.p. nominal. Class 5 consists of four vessels—namely, the *Warrior*, the *Black Prince*, the *Defence*, and the *Resistance* (the two latter being badly protected). These vessels are protected by 4½in armour, have a speed of 12 to 13 knots per hour, and carrying 9 ton guns and under. Class 6 consists of two vessels, namely, the *Pallas* and the *Favourite*, protected by 4½in. armour, having a speed of 12 to 13 knots per hour, and carrying 9 ton guns and under. Class 7 consists of two sloops—namely, the *Enterprise*, and the *Research*, protected by 4½in. armour, having a speed of 9½ knots per hour, and carrying 6½ ton guns, and three gunboats—namely, the *Viper*, the *Vixen*, and the *Waterwitch*, protected by 4½in. armour, having a speed of 9½ knots per hour, and carrying 6½ ton guns. We shall possess 11 turret and special vessels, carrying two guns, which are classed as follows:—Class 1 a new design, protected by 10in. to 14in. armour, having a speed of 12½ knots per hour, and carrying 25ton 12in. 600 pounders. Class 2 will consist of the *Monarch* and the *Captain*, protected by 7in. to 8in. armour, having a speed of 14 knots per hour, and carrying 25ton guns. Class 3 will consist of the *Glatton*, protected by 10in- to 12in. armour, having a speed of 9¾ knots per hour, and carrying 25ton guns. Class 4 will consist of the *Hotspur*, protected by 10in. to 14in. armour, and the second *Hotspur*, protected by 8in. to 12in. armour, both possessing a speed of 12 knots per hour, and carring 18 or 25 guns. Class 5 will consist of the *Royal Sovereign* and the *Prince Albert*, protected by 4½in. to 5½in. armour, having a speed of 12 knots, and carrying 12ton guns. Class 6 will consist of the *Scorpion* and the *Wyvern*, protected by 4½in. armour, possessing a speed of 10 knots per hour, and carrying 12ton guns. The grand total of these figures will give us 47 armoured ships, carrying 598 guns, of which 18 are 25tons, 9 are 18tons, and 111 are 12tons. Our unarmoured fleet may be described in general terms thus:—We have at the present time available for service about 13 old line-of-battle ships and heavy frigates, including the *Galatea* and the *Ariadne*. In addition to these vessels we have the *Inconstant*, heavy frigate, having a speed of 15 knots per hour, and carrying 12½ton guns; the *Active* and the *Volage*, large corvettes, having a speed of 15 knots per hour, and carrying 6½ton guns; 12 Blanche class corvettes, having a speed of 13 knots per hour, and carrying 6½ton guns; two of the *Druid* class, having the same speed and armament; 12 gun vessels of the new type, having a speed of 11 knots per per hour, and carrying 6½ton guns; and 17 composite gunboats, having a speed of 10 knots per hour, and carrying 6½ ton guns; besides others of the old type, including eight heavy corvettes. The total of our unarmoured fleet, therefore, will be 66 vessels, besides a number of old sloops and gunboats. It must not be forgotten that the maritime defensive and offensive power of England will consist in the future, not only of ships and guns, but also of torpedoes, of the importance of which the naval authorities of this country are fully alive. It is not an easy thing to make an accurate comparison between the strength of the navy of this country as it will be at the end of the next financial year and that of any other maritime power. But I may say that, in comparison with our 47 armoured ships, France will have 37, besides 11 floating batteries for harbour use. She, however, has no vessels that can compare with our first or second class broadside or turret ships, although she is strong in the third class. Her old unarmoured class is in better condition than ours, but she has only two or three of new type to compare with ours

## SOCIETY OF ENGINEERS.

### ON THE APPLICATION OF STEAM TO THE CULTIVATION OF THE SOIL.

By Baldwin Latham.

(*Concluded from page 65*).

4th Class.—Locomotive Engines moving along the Headlands or other part of a Field, and Drawing Implements by the agency of Wire Ropes.

The method of cultivating the soil by means of locomotive engines moving along the headlands is probably the earliest system of steam cultivation that was attended with any great success; and there can be no doubt but that, if the early productions of the machines of this class were only improved in the accessories to the system, or in the construction of the hauling appliances, these early inventions would have answered all the requirements of the more modern system. But in 1810, when Major Pratt first introduced this system, the country was not ripe for such an innovation as steam ploughing, and therefore to this fact may be due the very small success that attended the efforts of this inventor. One portion of Pratt's invention has been already described. The mode in which he carried out this portion of his invention is shown, and consisted in the employment of "three four-wheeled carriages, which travel along the field parallel to each other, with two endless chains extended between them, and passing around a single horizontal chain wheel on the outer carriage, and around a double chain wheel, driven by mechanical power, on the centre carriage. Ridge ploughs being attached to the chains, two ridges will be ploughed at the same time between the centre carriage and each outer carriage." The invention also included a mode of ploughing land when such land was intersected by cuts of water, which consisted in placing the carriage before mentioned on broad barges, so that the land could be cultivated up to the water's edge. The only drawback to the successful working of this invention was found in the chains, which were continually breaking. This apparatus of Pratt's, if fitted with a steel wire rope for hauling, would perfectly comply with all the requirements of modern culture.

In 1832, John Heathcoat obtained letters patent for his system and appliances for steam culture. His locomotive engine used has been already described under the head of traction engines. The machine already described was fitted with an endless floor made of strong sail-cloth and was adapted for the cultivation of boggy and swampy land. One portion of the invention had reference to mounting the locomotive on proper wheels when it was intended to be used on land sufficiently stable to support its weight. The general principle of the invention was similar to that of Major Pratt already described, and consisted in "employing auxiliary carriages, placed on each side of the principal carriage, at a distance from it, and parallel thereto. By means of ropes, bands, or chains, issuing from and actuated by the machinery of the principal carriage, and passing around a wheel, pulley, or barrel on the auxiliary carriages," the ploughs or other implements are drawn to and fro between the principal and auxiliary carriages. As the principal carriage travels along the field, the auxiliary carriages are caused to move at a corresponding rate." It appears, from the Paper on Steam Cultivation by Mr. James Howard, M.P., that Mr. Heathcoat spent no less than 12,000*l*. in developing his scheme, and that he was assisted in the prosecution of his invention by Mr. Joseph Parkes; and that one of his locomotive engines was completed and tried on 1st April, 1834, on which day, at the risk of its proving an April fool exploit, he drove it over a mile and a half of undrained bog. There can be little doubt that, had this invention been employed for the cultivation of high land, instead of for the purpose of dealing with those intractable extents of peat and bogs, great results must have accrued from the application, and the invention must have fully answered the purpose for which it was intended.

In 1839, Alexander M'Rae procured a patent for "machines for cultivating land by steam power, especially applicable to British Guiana, where the cultivated land is flat, or nearly so, and the fields are separated by navigable canals, which run parallel to each other, at a distance of from 240 ft. to 360 ft. apart." From this mode of working it will be seen that the invention is identical with the patented invention of Pratt in 1810, and differs but little in the mode of working from the appliances in use at the present day; for we see in this invention a rope or chain attached to the plough carriage is passed twice or oftener round the winding drum of the hauling engine, "it is thence led across the field (over several supporting rollers on the under part of the carriage" corresponding to the use of the modern rope porters), to a pulley on the anchor; and from thence it is led back and attached to the plough carriage; so that in this invention, which is by no means original, we have every feature of the modern plan of cultivating the soil where but one locomotive engine is used.

In 1846, T. J. Osborn introduced his plan of cultivating the soil through the medium of locomotive engines travelling on rails, and working the implements by ropes, which plan has already been described; but, as one portion of his invention is identical with those of Pratt and M'Rae, it is here mentioned. It has reference to cases in which the fields are bounded by navigable canals, when the engines were placed on boats or barges. In October, 1852, the late John Fowler procured his first patent for machinery that was self-propelling, which was intended to be used for the purpose of working drain ploughs. The engine was employed either to give motion to a drum to wind on a wire rope, and thus to move itself up to an anchor or fixed point on the land; or, in some cases, the inventor preferred to make his engine locomotive by "convenient gearing worked by the engine, so that the bite of such wheels upon the land shall act to drive the engine in the requisite direction."

In January, 1856, John Fowler procured a further patent for "improvements in machinery for ploughing land," which improvements are stated by the author of the invention to consist of combining an engine and hauling apparatus on the same frame in such a manner that the plough "is moved by a wire rope," while a second wire rope is used for moving "the engine and capstan from point to point along the headland." Improved anchors were employed in resisting "the movement of the engine, capstan or barrel, and pulleys" when working the ploughs, or the pulleys were so arranged that, instead of being anchored, they were made to "traverse along a rope fixed or anchored at each end."

In July of the same year John Fowler & Co. took out another patent for "improvements in machinery for ploughing and tilling land by steam." These improvements consisted in "giving motion to a plough or other tilling instrument by means of an engine on a carriage with two winding drums, mounted each on a vertical axis, such engine traversing on the headland as the work progresses so as to draw the plough, and working a plough or tilling instrument in both directions.,' By this arrangement the engine is employed to work the two drums, "so that whilst one is being driven by the engine the other is running free and unwinding its rope." Another portion of this invention had reference to the means of propelling "a plough or other tilling instrument by means of two engines, each on a carriage with a single winding drum, mounted on a vertical axis; such engines traversing on the opposite headlands, and each working so as to draw a plough or other tilling instrument towards itself." A further portion of this invention had reference to the construction of an anchor "carriage with disc wheels, which on being dragged along cut into the land, and the tackle (for drawing the ploughs), being fixed to the side of the carriage, is resisted by the wheels so sunk into the land." This patent also contains the necessary provision for applying the anchor in cases in which a fixed engine may be used to give motion to the ploughs.

In December, 1857, Messrs. Fowler procured a patent for so arranging the machinery, when two upright drums are used, that they may be "geared together," though this is "not essential," "as one of the barrels or drums may run freely." These drums or barrels work one or more drums or pulleys, fixed or anchored at a distance. The endless rope of wire or drawing tackle takes one or more turns around both the two upright drums or barrels and around the pulley or drum at a distance; and, in addition to dragging the plough, this invention embraces the mode of attaching a "harrow or other implement" to the plough in such a way as to act on the portion of the land ploughed or tilled in the previous passage of the implement over the land.

In April, 1858, John Fowler procured letters patent for his twin system of cultivation. The mode of working consists in applying two steam engines to haul ploughs and other agricultural implements in such a manner that the power of the two engines is applied at the same time to give motion to the implements. For this purpose two engines, each furnished with a pair of grooved drums, one or both driven by the engine, are placed opposite to each other, one on each headland, and an endless passes from one engine to the other and takes two or three turns round the drums of each engine. The implement is attached to the rope, and is hauled by means of it backwards and forwards over the land between the two engines according as they are working to wind the rope in one or other direction. The engines traverse along the headlands as the work progresses, and the length of the endless rope is adjusted according to the distance between the engines by winding up, or taking up, a greater or less length by means of the slack gear on the implement. The author of this invention claims for it the advantages derivable from using "engines of half the power of those which it is necessary to employ when the implement is hauled in both directions by means of one engine, or when it is drawn by two engines on opposite headlands, working alternately;" which advantage he considered lay in the fact that, when the engines were not required for ploughing, the smaller engines would be more useful for other farm purposes. On the report on steam cultivation in the Royal Agricultural Society's Journal for 1867, we find it recorded that this twin engine system was adopted by Lord Vernon on his estate at Widdrington, Morpeth, Northumberland, the engines in this case being fitted with clip drums instead of the drums already mentioned; but this plan of working was abandoned after a short period of work, as it was found that the two engines did not work amicably together. Mr. Clarke, in the report referred to, when speaking of this system and the results of its application on Lord Vernon's estate, says that "so much clock-work nicety is required that men could not work it," for "it was found that properly both engines (tied by a rope like Siamese twins) ought to start and stop exactly together, and this could not be obtained without electric communication between the two drivers, or rather (it would seem) between the reversing levers on the two engines. Another fault as compared with the "double," or winding apparatus was that more time was required for removal. Then the engines were considered too light to stand the great sideway strain, for on each alternate journey of the implement, No. 1 engine had to act as the anchorage of No. 2 engine, while at the same time No. 1 engine was pulling the plough with all its force. The fore wheels of the engines were shod with cutting-blade rims, which entered the soil like the discs of a travelling anchor; but, nevertheless, an unfortunate circumstance occurred: owing to the great sideway strain and the want of weight in an engine of this size (8-horse power) one engine broke the pin of its fore-carriage axletree, the fore end of the boiler tumbling over one of the wheels on to the ground. However, an hour and three-quarters sufficed to place it on its wheels again "without further injury;" and he adds that, "we must not be understood as condemning the 'twin engine' principle altogether, because it is possible that improved mechanical arrangements may make it successful, but the form in which it appeared at Widdrington was not found to answer. As we have said elsewhere, two engines working at once will probably achieve maximum results in steam culture, but with two implements instead of only one."

In 1859, Messrs. Fowler introduced their celebrated clip drum, which has been already described in connexion with another invention of a clip drum; there can be no two opinions of the great value of the clip drum in carrying on the various processes of tilling the soil. The wear and tear of the rope has been greatly reduced, while the mode of manipulation has been greatly simplified.

In 1859, Messrs. Collinson Hall procured letters patent for improvements relating to steam cultivation, which improvements consisted "in the employment of a single winding drum, with a continuous spiral on its periphery, on which the rope for drawing the implement is wound. The pitch of spiral is determined by the thickness of the rope, and the diameter and length of drum by the length of land required to be cultivated;" and they state that, "by coiling the rope once round the drum, sufficient tractive adhesion is obtained for overcoming the resistance of four ploughs;" but for a greater number of ploughs they advise a greater number of coils of the rope round the drum. They also state that, in ploughing, the improved drum may be fixed nearly in any position; but that they "prefer to place it around the boiler of the engine, from which the motive power is derived."

In June, 1861, John Fowler introduced an improvement in the travelling anchor, which improvement consisted in so arranging the anchor that the disc wheels may be set at any angle, so as to enable the carriage to be steered in any direction when travelling along a crooked headland.

In July, 1861, Messrs. Savory procured letters patent for "an improved winding apparatus," the improvements in which consisted in "applying certain mechanism to the barrel or cylinder part of the horizontal boiler of a stationary or portable engine, for the purpose of winding ropes or chains at pits' mouths, or for ploughing or other similar purposes." It will be seen that, so far as the invention of applying a drum round the boiler of the engine is concerned, Messrs. Savory had been forestalled by the invention of Messrs. Collinson Hall, which has been already referred to; but the mode of application, and of adjusting the winding rope, differed from Messrs. Hall's plan. The drums of Savory's engine are fitted round a horizontal boiler, and "are caused to revolve by suitable wheels or gearing connected with the engine;" and, for this purpose, they proposed to construct a drum of wrought iron with a suitable cast-iron head or ring at one or both ends, this ring to have teeth cast outside, to gear into a pinion or pinions on engine or other shaft. A part of the breadth of this ring is turned out true to run on a number of friction rollers on barrel of boiler. When two drums are used they may be constructed with a cast-iron head at one end and wrought at the other, with friction rollers as before; and for the purpose of guiding the rope on the drum, "a pulley is fixed on a horizontal spindle in a suitable frame, to receive or bear the rope from the plough or other thing to be drawn; two other pulleys are fixed on the same frame on vertical studs or spindles, with grooves turned in each to fit the rope, and placed one on each side of the rope, so that the grooves form a round opening for the rope to pass through; the frame is provided with suitable bosses with an internal screw thread cut in, to fit on a screw which is fixed by bracket or otherwise to frame of engine or boiler; this screw is placed so that the grooves of guide are opposite the periphery of drum where the rope runs, and connected with suitable wheels to the internal gear inside the drum ring. The pitch of the screw is proportioned so as to move the frame during one revolution of drum, a distance corresponding to a little more than the thickness of rope." In working, Messrs. Savory employ two engines, one on each headland. The winding drums of the engines are 6ft. diameter, and will each contain 550 yards of rope in a single lap. It appears from the report on the experiments on steam ploughing by the Royal Agricultural Society at Worcester, as recorded in the *Times* of July 21st, 1863, that "Mr. Fowler was 55min, moving with eight horses, and finished his two acres in 1 hour 51min. Messrs. Howard moved in 1½ hours with eight horses, and completed their two acres in 1 hour 57½min. Messrs. Savory moved in 25min. without any horses at all, and finished their two acres in 1 hour 40min. Mr. Smith moved in 1 hour with eight horses, and finished his two acres in 3 hours 1 min." The great saving of time, here recorded in favour of Messrs. Savory's apparatus, was due to the engines being of the locomotive type, the great superiority of which is shown in this special case; for, not only did they accomplish the task without the assistance of any horse labour, but they moved themselves from Gloucester to Worcester, "up and down hill," a distance of 30 miles in a single day, in order to take part in the experiments before alluded to. We find also, from a report in the *Mark Lane Express* of 17th August, 1863, that, at this trial at Worcester, the two 10-horse power self-propelling engines "did some tolerable work, considering the pace at which the grubber was driven."

The plot of nearly two acres was cultivated with the consumption of nearly 5¼ cwt. of coal, and calculating every expense, the cost would be something like 6s. 8d. per acre. This same report goes on to say, "The great advantage of the system is, that it reduces the wear and tear of the rope to a minimum. Having the rope but once coiled round those great drums, there is no crushing, grinding, or clasping action to wear it out, as in the other sets, and the ropes were paid out and wound up with well-regulated exactness. Mr. Clarke, in his paper on five years' progress of steam cultivation, when speaking of the results of the trials at Worcester, says, that in Messrs. Savory's arrangement the cylinders are necessarily of short stroke, giving out their full power only at a high number of revolutions per minute (unless at an excessive pressure of steam); and by driving the drum directly without reducing gear, too great a speed is obtained for any implement to work steadily. Travelling at a pace of more than four miles per hour (five miles per hour on light work), the implement not only makes imperfect work, but incurs great risk of damage from land-fast impediments; and, besides, a broader cultivator, at a pace of 2½ to 3 miles per hour, would waste less time, owing to the fewer number of bouts, each with its steady commencement and slackening of speed towards the close of the journey.

In May, 1862, Messrs. Fowler procured two patents for improvements in steam ploughing. The first of these improvements had reference to the mode of adapting the same engine for steam ploughing as is used in draining by steam power; and it consisted in fitting the engine with two drums capable of being driven at different speeds, having reference to the nature of the work to be performed. The invention also included a mode of temporarily removing one drum, and substituting for it another drum to be driven at a different speed as required. The second patent had reference to the appliances to be used in making the ordinary portable engine, as generally used by farmers, locomotive: for this purpose the apparatus for moving the engine, and for hauling the implements, consisted of a carriage having disc wheels attached by a flexible coupling to the engine. The carriage, containing the necessary winding drums for hauling the cultivating apparatus, and also a small drum, which receives motion from the driving powers, and winds up a rope laid out along the headland, thus drawing the hauling carriage and engine forward. The great improvement in this case appears to arise from the flexible coupling with the engine, combined with the disc wheel of the carriage. Appliances of the same arrangement, for hauling ordinary portable engines, had been previously in use; but, a rigid connection having been made between the carriage and engine, it was found inconvenient, for in hauling there was a great tendency for the engine to swing round. The application of the disc wheels entirely prevents any lateral movement, and therefore the application of this plan, in cases in which ordinary portable engines are already employed on a farm, will be attended with good results, as some of the advantages of a locomotive ploughing engine will be secured without the great cost of providing a locomotive engine having to be incurred.

In 1863 Messrs. Howard procured a patent for a locomotive engine for working cultivating apparatus. The engine frame was carried by three or more wheels, and upon this frame the barrels for carrying the traction ropes are mounted. These barrels are driven by gearing direct from the crank shaft, which runs longitudinally of the engine frame, and passes through a divided boiler situate at the end of the framing, and by adopting the contrivance of eccentrics (which have been already described in the description of the improved windlass), the barrels can be put in and out of gear at pleasure. The boiler of the engine is of vertical tubular construction, but made in horse-shoe section so as to allow the steam cylinder being placed within the lines of the boiler. The engine was made self-propelling by a mitre or bevel wheel keyed on the rear end of the crank shaft, which gears with a similar wheel keyed on a transverse shaft at the back of the boiler, to the extremities of which shaft friction discs or coupling are attached. In a line with this shaft are two shafts (one at either end thereof), carrying friction discs or their equivalents for establishing a connection between them and the central driven transverse shaft. These shafts have an endway motion in their bearings, and they carry at their extremities pinions for gearing into rings of teeth on the hind carrying wheels, or pitch chains, or other suitable modes of driving may be employed. The friction couplings are kept out of action by springs; but, when the machine is required to be propelled, these friction couplings are brought into action by the end of a screw. The engine is steered by means of a segment rack and pinion in connection with the leading wheel; but, at the same time, the machinery is so arranged that the movement of the front or guiding wheel influences the driving wheels of the engine, so that one wheel remains quiescent while the other is being driven, and in this way the engine is capable of being turned in a very limited space.

In March, 1864, Messrs. Howard procured a patent for a twin-engine system, differing from the system of Fowler, which has been already described. This invention had for its object the combination of the power of two small engines working simultaneously, so as to make two small engines available for the work that has hitherto required two engines of far greater power. In this mode of working, two winding drums, on to which a drag or hauling rope, and a driving rope are respectively coiled and uncoiled alternately, are used. The ropes are stretched across the field, and the implement is attached to the drag or hauling rope between one pair of drums. Between the other pair of drums is stretched a driving rope, so that one engine simply communicates the power to the other engine, thereby combining the power of the two engines. This system is also applicable to the "Smith's" or roundabout sytem; but this mode of combining the power is still open to many of the disadvantages that have already been mentioned in connection with Fowler's twin system, and is not likely to come into general operation. Another portion of this patent had reference to novel arrangements in the engines hitherto used by Messrs. Howard, which consisted in mounting the boiler so that the tubes or flues will run at right angles with the travelling wheels, and in providing a strong central shaft, running at right angles to the axles of the travelling wheel, on which shaft the winding drums are mounted on eccentrics, in a manner that has been before described. Another arrangement consisted in the use of a large winding drum, similar in many respects to that used by Savory, but mounted in a different position.

In May, 1864, Collinson Hall procured letters patent for a number of minor arrangements in steam cultivation, principally consisting of the mode of applying the power of two or more engines to work one winding drum, the use of a travelling railroad for supporting the engine employed in cultivation, the use of travelling porters, and, lastly, in the employment of two sectional drums of different diameters, or with a different number of sections on the same shaft, for the purpose of regulating the tension of the rope by shifting it according to requirement from one drum to the other.

In October, 1864, Messrs. Coleman and Morton procured a patent for a mode of applying steam power for the cultivation of the soil. The mode of working consists in employing two steam engines, one at each side of a field, for the purpose of traversing the implements to and fro in tilling the land, such engines both operating simultaneously on the same rope by which the implements are propelled; but instead of using only one implement as had hitherto been the practice, Messrs. Coleman and Morton employ two single and detached sets of implements, the one being attached to the one part of an endless rope, and the other to the other part. One implement traverses from the engine on the headland at one side to the middle of the field, while the other traverses from the middle to the engine at the opposite side of the field, and are so arranged that while one is tilling, the other is going back without operating on the ground. By this means the one engine is pulling directly on one implement while it is tilling; and the other engine is pulling directly on the other which is being dragged backwards over the ground, while at the same time its surplus power is transmitted by same rope to the drum of the other engine and to the other part of the rope hauling the implement in work, thereby assisting in the traction of that implement also. Another portion of the invention of Messrs. Coleman and Morton has reference to an improvement in winding drums, which consists in an arrangement for traversing the rope on the drum so that it arrives and leaves the drum at the same point, and the rope always maintains the same relative position on the drum, without riding, or surging, or slipping in a lateral direction. The last time that these appliances of steam culture entered into competition trial was at the Royal Agricultural Show in 1864, when the silver medal of the society was awarded them, and the judges commended the work performed by this apparatus. Messrs. Coleman and Morton also have a mode of working two implements merely half way, from a single engine on one headland and an anchored pulley on the other.

In February, 1865, James Howard procured a patent for "improvements in steam engines applicable to ploughing and other agricultural purposes," the object of which was, by a novel arrangement of the engine and boiler, to increase the efficiency of the machine. These improvements consisted in making the firebox midway of the length of the boiler, and having a smokebox or flue at either end of the boiler. These smokeboxes he proposed to connect with the firebox by a system of tubular flues running longitudinally of the boiler, which flues were to be made tapering in form, the largest end being next the firebox. The barrel of the boiler was also to be tapered in the same way as the tubular flues, and the heated gases were led off from the two smokeboxes to a central chimney over the firebox, within and at the base of which chimney the steam dome is situated. From this steam dome the steam is taken and conducted by a pipe or pipes through a heated flue to the cylinder or cylinders of the engine situate on the top of the boiler. The advantage claimed for this arrangement is, first, a rapid generation of steam, and, secondly, the supply of dry and superheated steam for the engine. In this arrangement of engine the winding drums for hauling the implements are placed at each end of the boiler, and are set in a longitudinal shaft, which is carried in bearings supported by the shell of the boiler.

In October, 1866, Messrs. Howard procured a patent for an improved mode of working steam-tilling implements, which has been called the "double-double system." The mode of operation consists in combining the power of two engines in working two implements, so that each implement and hauling apparatus is quite independent of the other. The method consists in operating with two engines simultaneously, the engines being placed at opposite sides of the field; and, as each engine has "two winding drums, which are geared to the driving shaft, independently of each other," one drum on each engine may be winding while the other drum of the same engine is standing still, or may be unwinding its rope. Between the two engines two distinct lines of rope are placed, and connected with the winding drums of the respective engines. The implements are attached to the hauling rope, and the tilling is so arranged that the field is divided into two parts for the purposes of culture, the two implements traversing half way, or any other proportion of the distance between the engines. In this engine the boiler is placed transversely across the frame of the carriage, which is considered by Messrs. Howard to be a great advantage when travelling up and down an undulating country, the water line of the boiler not being so subject to the disturbing influence as is the case when the axis of the longest diameter lies in the direction of the moving body; on the other hand, it is contended that this arrangement of boiler is highly prejudicial, if the engine is at any time employed to work on a sloping headland. The advantages of the double-double system are very great, when it is seen that both engines are kept at work during the whole period of working, and that two implements are worked at the additional cost only for an extra ploughman and porter boys; and that relatively a much larger proportion of work can be completed within a given time by this mode of work that can be possibly secured in the double-engine system, when each engine works alternately. Mr. Clarke, in the Report of the Committee of the Royal Agricultural Society, speaking of this mode of working, says, "the plan is promising, as will appear from a contrast very easily made in figures. Suppose that, on the old double-engine system, one implement, 7 ft. wide, traverses from engine to engine to engine in 200 seconds, and takes 10 seconds to turn; that is, a strip of land 7 ft. broad, and the whole length of the field, is cultivated in 210 seconds. Now take the same two engines in the same position, but with two implements meeting midway. There being two plys of rope instead of only one, we must reduce the width of each implement to say 6 ft., in order that the engine may be able to pull it at the same pace as in the former case; say then that two 6 ft. wide implements travel at the same pace, they will accomplish their half-way journey in 100 seconds. Then as the engines have to shift forward on the headland, while the implements are at the ends, a longer time will be wasted—say 20 seconds in 'turning' at the end: that is, the half-journey is accomplished in 120 seconds. But then, as there are two 6 ft. implements simultaneously travelling, a strip of land, 6 ft. broad, has been cultivated the whole length of the field between the two engines. The comparison is this: the double-engine system has tilled a foot breadth (of the whole length of the field) in every 30 seconds: whereas the double implement and double-engine system has tilled a foot breadth (of the same length) in 20 seconds. In other words, the new plan is capable of working as large an area in two hours as the old plan can do in three hours; or, in other words again, you may henceforth get your six weeks' work of autumn tillage finished in four weeks, and for much less money; because, while there is an additional ploughman, with a slight increase in coal, oil, and water-bill, you have only two-thirds the number of days on which expense at all has to be incurred."

It should be here mentioned that Messrs, Fowler have also worked two implements by two engines at the same time, on a plan somewhat different from this system of Howard's, and also differing from the twin-engine system already described. The implements used in this case were a plough and a cultivator, and they traversed the full length of the field the cultivator working on the land that had been previously ploughed.

Messrs. Howard's engine, with the winding drums placed at the extreme ends of the engine, is very favourable for carrying out this double ploughing system. The principle objection to this plan of working lies in the bad work that is said to be made at the points where the work of the respective implements is joined, and it certainly would be a further improvement if the space between the ploughing implements could be so adjusted that each implement may traverse the full length of the field; for, not only would time be saved in turning, but the work, especially ploughing, could be performed in a better style: probably this might be done by so arranging the distance between the driving pulleys that they shall always be exactly distant from each other, a space equal to the breadth of the land to be ploughed, and after each length traversed the two engines must be moved forward the distance equal to the breadth of the space that is covered by the tilling implement.

### RELATIVE MERITS OF STATIONARY *versus* LOCOMOTIVE ENGINES WHEN TILLING THE SOIL.

That each of these systems of working has its merits and its drawbacks cannot be denied, and it often becomes a difficult question for the farmer to decide which system he shall adopt with the greatest advantage. The partisans of each system are often found praising the system and appliances they may have adopted, and which have proved on their lands to have answered the purpose for which it was applied; and they are not unfrequently led, by the bigotry originating in the success of their own appliances, to decry some other system, the mode of working which or the conditions under which it may have been adopted being unknown to them.

It is not the author's intention to decry either system, as good results have been unmistakably proved to have been obtained in the application of both; but, with the knowledge of all that has been done in the way of steam cultivation, it cannot be a very difficult matter to decide which is best adapted to the conditions under which it may be desirable to work it. There are a few points in considering this part of the question that it will be well to inquire into. It must be granted that an engine that is self-propelling is vastly superior to one that requires the labour of a large number of horses to move it from one position to another; but as a self-propelling engine may be used on either the stationary or locomotive systems of cultivating the soil, this portion of the question need not be discussed when considering the principles of the application or the respective systems. Neither need we take into consideration the nature of the appliances the farmer may be in possession of when he is about to adopt steam power, because we see, from what has already been done, that the ordinary portable steam engine, as found on a great number of farms, may be adapted to be used in carrying out either one or other of the systems. The principal question that first arises is that of cost. It is very clear that the roundabout system with stationary engines has been less costly than the system of locomotive engines working the implements more directly, and therefore, looking at the relative systems in respect of cost, we must bear in mind that the interest on capital and depreciation of stock virtually represent a fixed charge per acre on the land cultivated, and the smaller the acreage to be cultivated in proportion to the capital expended, the greater the cost of cultivation; and it therefore follows that, on small farms, the least expensive apparatus will be found to be the most economical, provided the ordinary working charges for coal, oil, and labour are not disproportionate to the area cultivated.

It has been already mentioned that a locomotive engine will be found vastly superior on the farm to one that requires the labour of horses to move it, and therefore it will probably be found that, in most cases, when the farmer is purchasing entirely new machinery, he will procure the self-propelling engine; and, having got a machine of this description, he will be able to use it either as a stationary engine, or as a locomotive travelling along the headlands. The advantages of the travelling engines are very great when considered in a strictly mechanical sense, because it will be seen from the mode of working that the power of the engine is transmitted to the instrument used in tilling in the most direct manner and with the least loss of power, as the number of pulley and the length of rope are reduced to a minimum. That the locomotive system has its drawback cannot for a moment be denied, and these drawbacks arise from having the power constantly on the move, thus requiring coals and water to be carted after it, and leading to an increase in cost on this account; moreover, it is found that occasionally, immediately after rain, it is difficult to get the engine to travel over the unprepared headlands of our fields; whereas, on the roundabout system, the machinery can at once be put in motion, as its movements are so far independent of the state of the soil; but it should be borne in mind, as a set off to this drawback, that the direct acting system of tilling land with the locomotive engine when at work is capable of performing a greater amount of work per day than a stationary engine of equal power, as there is considerably less time lost in the various changes, in fixing and starting the appliances for work, and in the economy of the application of the power. As farms are at present laid out in small plots, there is no doubt that there is some reason in the arguments of the opponents of the locomotive system, when they tell us that the weight of a heavy locomotive, travelling over the head lands, is destructive to the fertility of a very large area of land; and that the mischief caused by the movement of the ponderous machine over the ground is further increased by the cartage of coal and water to supply the wants of the machine; but it will be seen that these arguments apply rather against the present plan on which our farms are laid out, than against the adoption of this mode of steam cultivation; further difficulties would be obviated by the removal of useless hedges and the construction of properly formed roads. The question of water cartage may be dismissed; for, whether we have locomotive or stationary engines, as a rule the cartage of water will be required, although it is quite possible with the stationary engine system so to lay out the farms that the cartage of water should not be required.

In considering this question of the merits of stationary *versus* locomotive engines, it will be well to inquire which is the best method of each system to be followed. So far as our present experience goes, it has been shown on large farms that the double-engine system offers great facilities for cultivating the soil most effectually, whether used as a stationary engine or a locomotive. Two stationary engines when at work have out but half the length of rope that is required with the ordinary roundabout system worked with one engine. Two engines on the locomotive plan with winding drums have out but half the rope required when but one engine is used, and therefore there is a saving by reason of frictional resistance due to the smaller quantity of rope at work, but this gain is to some extent counterbalanced by the larger percentage of fuel used when the mode of working that has hitherto been in use, is adopted—of working the two engines alternately. We find, from the report of the Committee of the Royal Agricultural Society on steam cultivation, in that part of the report prepared by Mr. Reed, that "the double-set consumes in the same space of time 35 per cent. more coal than the single set," but this loss in the consumption of fuel will probably be soon removed in the case of the locomotive system, when what is termed the "double-double system" of cultivation comes into full operation, and therefore when this drawback is removed the locomotive system will be found to be superior to the stationary system.

The difference between the stationary engine and the locomotive engine lies principally in this, that in the locomotive system the heavy engine is moored a comparatively short distance along the headland, while in the stationary system an additional length of rope is used, which has to be moved a great number of times through the space that would otherwise be traversed by the locomotive. For example: Take a field 400 yards long and 300 yards wide, with a single locomotive engine, as compared with the roundabout system, taking the movement of the anchor as equivalent to the friction in the pullies of the roundabout system, we find that 800 yards of rope, additional to that required in the locomotive system, are required to be moved in the other system; assuming that, at each traverse of the tilling instrument 5ft. of ground is covered, the number of times the extra 800 yards of rope will have to pass through the space, that would be traversed by the locomotive employed to do the same work, will be 240 times; and, assuming that the rope weighs $1\frac{3}{4}$lbs. per yard, we get the result $800 \times 240 \times 1{\cdot}75 = 150$ tons; or 150 tons moved through 400 yards under the roundabout system, against 10 tons, the weight of an agricultural locomotive, moved through the same space on the locomotive system.

The advantages of the locomotive system with its comparatively short length of rope laid out in perfect straight lines is seen when the respective systems come to be put in operation, for it is very much easier to lay out the rope on the locomotive system than on the roundabout, when it requires to be carried all round the field.

With the stationary engine it is possible to work closer to the hedges, and therefore in small enclosures this is a great advantage, as the amount of work left to be performed by horse labour is reduced to a minimum; indeed, in some cases under the stationary system, it may be possible to so lay out the land that the engine may be set down by the side of a tank or pond, and so all the cost and trouble of carting water may be avoided. The chances of damage to the engine, by the carelessness of the driver in allowing the implements to run into it, are not so likely to occur in the stationary as in the locomotive system.

In practice it is found that the farmer requires a good and efficient tool with as little outlay as possible. The question of loss of time and other matters are naturally put on one side, because in many instances the farmer cannot afford to pay the cost of procuring the most perfect apparatus; he is content with a machine that will perform all the work he requires, and on this account the stationary engine, as being the cheapest, will commend itself to the small capitalists, while the large capitalists will provide themselves with more perfect appliances. The roundabout system with the ordinary portable engine will be found the cheapest appliances for small holdings; the larger farms will be more cheaply worked by the more expensive appliances, when those appliances are capable of performing, in proportion to the cost, an increased area of cultivation.

## THE INSTITUTION OF CIVIL ENGINEERS.

### ON SINKING WELLS FOR THE FOUNDATIONS OF THE PIERS OF THE BRIDGE OVER THE RIVER JUMNA, DELHI RAILWAY.

By Mr. Imrie Bell, M. Inst. C.E.

After alluding to the native plans of sinking wells, built of masonry or brickwork, by excavated the sand from the interior, at first by means of a spade called a 'phaora,' and after the first 5ft. by an implement called a 'jham,' reference was made to a modification in the use of the 'jham' in constructing the railway bridge over the Jumna at Allahabad, where instead of sending down a diver to force the spade into the ground, a pole was employed to strike the butt end of the 'jham' and so to drive it into the ground. This was, in the Author's opinion, a decided improvement; but the process was still tedious and slow, especially where clay or hard strata were met with.

The Author then proceeded to describe the mode of forming the foundations of the bridge over the river Jumna, near Sirsawa, on the Delhi Railway. It appeared that the bed of the river at this point consisted of coarse and fine gravel and sand, interspersed with layers of blue clay 3ft. and 4ft. thick, and covered with silt; but during the rainy season large boulders, weighing 14lbs. each and upwards, were brought down, and deposited by the scour of the river 30ft. below the level of the bed. The bridge comprised twenty-four openings, each 99ft. in the clear, and the superstructure was composed of two lines of lattice girders, resting on brick columns, or wells, each 12ft. 6in. external diameter, and 5ft. 10in. internal diameter, so that the wall of the well was 3ft. 4in. thick. In some instances the sites of the piers were got clear of water by diverting the river at different points during the dry season, while in other cases islands were formed, by driving a half-circle of piles on the up-stream side, then lowering sand bags on the down-stream side, to the height of 4ft. or 5ft. and afterwards filling up with sand to 5ft. above low water. The curb on which the steining of the well rested was formed of wrought-iron plates and angle irons rivetted together; and in cross section the curb was like an inverted right-angle triangle, of which the height was 4ft. and the base 3ft. 4in. When each curb was complete, it was moved into position, and the compartments were then filled in with concrete. The curb was next sunk by men working with the 'phaora' and basket, till the upper edge was within 3in. of the level of the water, when a ring of brickwork was carried up for a height of 6ft. The excavation of the interior was again proceeded with, by means of the 'jham' and divers in the old native style; afterwards a further height of 10ft. of brickwork was added, but the material was now removed by a sand-pump (to be hereafter described) worked by a steam hoist of 4 H.P., as was the case after two additional lengths, each of 15ft. were built, when the well was carried down to its full depth. In operations of this nature great care was necessary, especially at first, to insure the well, or cylinder, descending vertically. For this purpose the curb should invariably be sunk alone without any building. The first height of brickwork should not exceed 5ft. or 6ft. the next 10ft. and it was never advisable to build more than 15ft. at a time. Before commencing any additional height, the top course of the brickwork already built ought to be removed, to insure a thoroughly clean surface for the mortar.

The lime used at the works was made from marl, or, more properly, calcareous clay, which, while soft, was roughly moulded into bricks. These were stacked to dry for three or four days, and were afterwards burnt with wood in kilns for fifty or sixty hours. The flues were then closed with bricks and mud, and so allowed to remain for two or three days. On the kiln being opened, the lime bricks were unloaded almost in a whole state, were ground under stones, screened, and carried to the works pure and free from ash or dirt. The mortar was made from one part of ground lime and one part of clear, sharp sand. This mortar was used in all the well foundations of the bridge up to the level of low water; and as a proof of its quality it was stated that it was easier to break the work as a mass, than to separate it at the joints or beds. Above the level of low water the mortar was composed of white hill lime, and soorkhee, or crushed brick bats, in equal proportions, as it was found that the lime from the calcareous clay lost the greater part of its cohesion when used in work exposed to the vicissitudes of the atmosphere—whether this arose from the frequent changes from dryness to humidity, or from heat to cold, was not ascertained.

The well sinking for the foundations of the piers and the abutment of this bridge was completed in little more than two years, which, without deducting any time for building up the brickwork, or for that unavoidably lost by the rise in the rise in the river during rains, gave an average rate of 159ft. per month. The time occupied in the building of the steining of the wells, erecting, taking down, and re-erecting scaffolding and staging for sand pump, weighting the wells, etc., was equal to that emplyed in sinking. This would give the rate of sinking as a little over 300ft. per month. If cast-iron cylinders had been used, the work could have been performed much more quickly, as the portions of the cylinders could have been put together more rapidly, and owing to the slight bearing surface exposed by the thickness of the iron, compared to the breadth of brickwork in the walls of the well. The total weight of the foundations and of the iron girder superstructure on each well was 420 tons, and the area of the bottom of each well was 117ft. so that the weight was less than 4 tons per square foot.

The novelty in the sinking of the wells of this bridge was in the use of the Sand Pump. This was described to consist of a wrought iron cylinder having a pump rivetted to it at the top, in which was a piston fitting loosely, and pierced with small holes to allow of the escape of water. The piston rod terminated in an eye at the upper end, to which a chain could be attached. The bottom of the cylinder was moveable, and in the centre there was an upright suction pipe, projecting outwards for a distance equal to its own diameter, and inwards nearly to the top of the cylinder. When the pump was lowered to the bottom of the well, the chain attached to the piston rod was worked up and down like a ringing engine. In this way water was first drawn through the upright pipe, followed by sand or other material, which fell over the pipe into the cylinder. This operation was continued until the cylinder was quite full, which was known by the piston working stiffly, when the machine was raised to the surface; the bottom of the cylinder was then detached, with the column of sand resting on it, and another cylinder bottom which had been cleared of its sand was substituted. The number of men employed at each well was fourteen; nine working the chain, two clearing away the stuff brought up by the pump, one in charge of a steam hoist, one breaking firewood, and an overseer. The average rate of sinking, including contingencies, was about 6ft. in eight hours. This rate was extraordinary when compared with the old system of the 'jham' and diver, and would, it was believed, materially reduce the expense of bridge work in India.

In conclusion, reference was made to other methods adopted in this country for sinking cylinders; particularly to a machine on the dredger principle, which had been used in the construction of the new bridge over the Clyde at Glasgow, and to the Excavator which had been employed in sinking the cast-iron cylinders for the foundations of the piers of a railway bridge over the same river, and which formed the subject of a separate Paper. On considering the different plans, the Author stated that he thought most favourably of the Sand Pump of Mr. Howard Lennard (Assoc. Inst. C.E.), as from its simplicity it was peculiarly adapted for India and for localities where skilled labour could not readily be procured. Some improvements which had been effected in the details were then described, particularly in the substitution of the moveable bottom for the side doors as originally made, and in adapting the pump for piercing clay at the Sutlej Bridge Works.

## DESCRIPTION OF APPARATUS FOR EXCAVATING THE INTERIOR OF, AND FOR SINKING, IRON CYLINDERS.

By Mr. John Milroy, Assoc. Inst., C.E.

It was believed that, for the purpose of sinking cylinders, the great desideratum hitherto had been some method of excavating the earth from the interior without at the same time having to take out the water, and to keep it out during the operations. This object seemed to the Author to have been attained by a machine of his invention, which was used in the construction of the bridge over the river Clyde, for the Glasgow (City) Union Railway, to which Mr. Fowler (Past President Inst. C.E.), and Mr. Blair (M. Inst. C.E.), were the engineers.

The excavating apparatus, commonly called the 'Excavator,' was thus described:—It consisted of a horizontal frame of iron, with an outside rim 9in. in height, to which radiated, like the spokes of a wheel, T irons from a small cast iron ring in the centre. To the bottom of the outside rim were hinged eight heavy iron spades, which, when drawn in, fitted closely, with their points pressing against the inner ring. The hinges of the spades were so constructed as to prevent them from turning back beyond the perpendicular. The whole apparatus was very strongly made, and it formed when closed a nearly water tight tray. When the machine was descending, the spades were allowed ot hang vertically, and they were forced into the ground, by the aid of two chains, fastened to the top of upright arms on opposite sides of the Excavator, then passed down the cylinder, under a pulley, up between two leaders, and over another pulley, the end of each chain being wound round the large axle of a capstan, or drum on the landing stage. These chains were calculated when tightened to keep the machine down, whilst the spades were drawn in through the ground, and up to the frame. This was effected by a second set of chains, all of equal length, and each fastened at one end to the inside of a spade and at the other to the end of a main chain, by which the machine was raised to the surface, with the earth it contained, by means of a steam hoist. In order to enable an opinion to be formed of the capabilities of the Excavator, it was mentioned that the progress of the excavation, and the corresponding subsidence of the cylinder, reached from about 13ft. to 20ft. per day of ten hours, inclusive of the time employed in adding fresh lengths of cylinder, putting on weights etc. When there had been little interruption for any of these purposes, it had amounted to 25ft. in the ten hours, and then the average quantity of sand brought up at each lift was 21 cubic feet, and the total quantity during the day was found by measurement to be 70 cubic yards. Twelve men in all were employed,—viz., one engineer, one stoker, six men working the drums, three attending to the loading and discharging of the Excavator, and one man wheeling away the materials.

In conclusion the following advantages were claimed for this apparatus:—First, That it was perfectly independent of water, which was allowed to remain in the pit or cylinder until the excavation was completed; Secondly, That it could be used, and was equally effective, at any depth, without sensible difference in the cost of working; Thirdly, That its rate both of sinking and of excavating was higher than had yet been attained by any other method; And lastly, That it was not liable to get out of order, whilst its action was always in the same perpendicular line, and the expense attending its working was comparatively trifling, as skilled workmen were not required.

At the Monthly Ballot, the following Candidates were balloted for and duly elected as members: Messrs. W. J. Forrest, J. Johnson, H. N. Maynard, and E. B. Scott; as Associates, Messrs. C. Barnard, J. H. Blake, H. Chubb, A. D. Fox, R. A. Robertson, Major J. H. M. S. Steward R.E., Captain E. T. Thackeray, V.C., R.E., and Mr. F. Turner.

It was announced that the Council, acting under the provisions of Section IV. of the Bye Laws, had recently admitted as Students of the Institution, Messrs. J. G. Barton, H. M. Bell, H. W. Dallas, T. Inman, S. Moyle, and H. O. Smith.

## AMERICAN LOCOMOTIVES AND ROLLING STOCK.

By Mr. Zerah Colburn, M. Inst. C.E.

It was remarked that, in construction and working, the American railways represented little more than a modified application of English practice. When the systems of the railway machinery of the two countries were compared, many of the differences which first struck the eye were found to be external rather than fundamental; and so, too, many of the peculiarities of construction now retained in America were due to the initiative of English Engineers.

Pursuing the history of the introduction of locomotives into the States, it was observed that the first two worked in America were made in England, in 1828, one by Mr. George Stephenson, the other by Mr. J. U. Rastrick. In the same year the Engineers of the then contemplated Baltimore and Ohio Railroad visited this country, when Mr. Robert Stephenson suggested to them, what was now the distinguishing feature of all American railway rolling stock, viz.: the bogie, to be applied to the engines intended to work round curves of 6 chains radius, at that time proposed to be adopted. The bogie, which had grown out of William Chapman's invention of 1812, was then, Mr. Stephenson stated, in regular use upon the quays of Newcastle. Having regard to the character of the lines first constructed in the States, it was essential that the locomotives should be light and cheap, and the first engines made there between 1830 and 1832, weighed only from 3½ tons to 4 tons. Some of the English built engines imported at about that time had their leading wheels removed, and a swivelling bogie substituted. The bogie was not, however, exclusively employed. Considerable numbers of engines made by Messrs. Stephenson and Co., Messrs. Bury, Curtis, and Kennedy, Messrs. George Forrester and Co., and Messrs. Braithwaite and Co., were afterwards imported and worked as originally constructed; and as late as 1855, at least one hundred locomotives of English construction, or made almost exactly upon Messrs. Stephenson's plans, could have been counted at work in the States. For many years wood only was employed as fuel, and as it produced great quantities of sparks, as annoying to passengers as they were dangerous to goods, much ingenuity was directed to the problem of separating and withholding them from the escaping smoke and steam; and the voluminous 'spark arresters' were very successful in this respect, while they gave also an individuality to the engines. Again, the rigours of the American winters compelled the adoption of some kind of shelter for the enginemen and firemen; and this was afforded by the bulky, and often extravagantly painted, 'cabs,' which imparted a novel appearance, but without in any way affecting the principles, or economical conditions of working, of the engine.

As high speeds were seldom attempted upon the early American lines, the greatest steam tractive power was sought and obtained, both by working high-pressure steam and by employing driving wheels of small diameter. Thus, although, in 1835, the English built engines, and those copied from them, were worked at 50lbs. pressure, and had 5-feet driving wheels, it was not long before American practice settled upon 90lbs. to 100lbs. pressure and 4-feet or even 3-feet-8-inch driving wheels. It was soon found, however, that the adhesion weight upon a single pair of wheels, necessary to work up this increased steam tractive force, was too great for the strength of the way, and coupling was then resorted to; and now, with the exception of a few light tank engines on branch lines, there was not probably an engine in the States having single or uncoupled driving wheels. Four tons might be said to have been the maximum per wheel for many years, while three tons was the more usual average. Compensating levers, generally made of long steel springs, were now employed on all American engines whereby the weight was not only equalised between the coupled wheels, but the effect of a jolt upon one pair was divided and distributed, through the springs and levers, upon the other pair. For some years, too, the bearings of the outer ends of the springs of the coupled wheels were made to rest upon india-rubber blocks.

The details were then given of several descriptions of engines long worked on the Baltimore and Ohio and Reading railroads, as well as of that employed to work the incline of 1 in 16¼ and 1¼ mile long, at the Madison terminus of the Madison and Indianapolis railway. Compared with English practice, in which six wheeled coupled engines had from 5 tons to 6 tons on a wheel, and eight wheeled coupled engines had 7 tons on a wheel, it was observed that the subdivision of weight in American engines was carried about half as far again, or, in other words, that they averaged only about two-thirds as much weight per wheel, and that they thus required, for a given total weight, half as many more wheels. Except with smaller wheels, this could not be done on any practicable length of wheel base; but none of the American goods and bank engines, of which the particulars had been given, had wheels larger than 3 feet 11 inches in diameter. There were objections also, of much weight, to coupling a large number of wheels from a single pair of cylinders. It was more or less difficult, if not impossible, to preserve an exact equality in the diameter of the wheels, an exact parallelism of the axles, and an exact equality in length of the coupling rods. The extent to which coupling had been carried in American goods engines had been due, in a great measure, to the following expedients. The coupled wheels were as equally loaded as possible; their tyres, in a majority of cases, were of chilled cast-iron, since replaced by steel; and the former were cast, and the latter turned, nearly or quite to a cylindrical form, or with but little or no cone. The driving wheels were the middle pair, or, in the case of an even number of pairs, one of the pairs nearest to the mid-length of the wheel base; compensating levers were employed, and adjusting wedges had for some years been applied to the axle-boxes. The coupling rods, in many cases, were made without brasses, round steel bushings being fitted to circular eyes formed at the exact required distance apart in the ends of the rods. With the exception of the leading and trailing wheels, the coupled were generally fitted with plain cylindrical tyres having no flanges. Outside coupling cranks, necessary with outside frames, had rarely been employed, and were never so now. The coupling rods were counterweighted within the wheels themselves, no attempt being made in inside cylinder engines, to set off their weight against that of the cranks and attached parts. In other words, the coupling pins of the driving wheels were coincident, on each side of the engine, with the position of the crank in inside cylinder engines, and, of course, necessarily so in outside cylinder engines. The experience of American locomotive engineers had been to the effect that with this arrangement, which was the opposite of English practice, the axle-boxes wore more uniformly, and that there was less 'knocking' where a little play in the horn plates had once begun. And lastly, the length of the crank being one-half the radius of the small coupled wheels employed, any inequality in the length of the coupling rods was attended with less slipping and binding than where, with larger wheels, the crank was but about one-third the radius of the wheel.

The general form of passenger engine now in use in the States was then described. It had in most cases outside cylinders—indeed inside cylinder engines had not been built for many years—and it had invariably four coupled driving wheels, and a four-wheeled bogie. The leading dimensions of the representative type of passenger engines were—cylinders from 15 inches to 17 inches in diameter, with a length of stroke of from 5 feet to 5 feet 8 inches in diameter. Such engines would exert a tractive force of 3½ tons to 4 tons in starting, for which their adhesive weight, assisted sometimes by sand, was sufficient; and thus they could get quickly away from stations even with trains of a gross weight of 200 tons or more. Economy of fuel had not been studied to the same extent in American as in English locomotives: the blast pipes of the former were smaller, the draught more forced, the back pressure greater, and less expansion was attempted in the cylinders, the link motion being generally arranged to cut off at one-third stroke as a minimum, and at nine-tenths or more as a maximum. It was thus that boilers of moderate size were made to supply steam for work equal to 300 I. H. P., or the exertion of upwards of 2 tons of draught upon a passenger train at a mean speed of 25 miles an hour; but there was nothing remarkable in the consumption of from 50lbs. to 60lbs. of coal per mile in such work. It was stated that on the Pennsylvania Central railroad, a line 356 miles long, with gradients of 1 in 100 and 1 in 55, the consumption of coal for both goods and passenger trains amounted on an average to about 70lbs. per train mile, the goods mileage being three and a-half times the passenger mileage. The coal was of excellent steaming quality, and cost about 3½*d.* in currency, or 2½d. in coin, per train mile. At this rate a difference in consumption of 24lbs. of coal per mile would only cause a variation of a penny per mile in the cost of fuel; and it had been argued that such a waste was better than the alternative of employing an engine 4 tons or 5 tons heavier, to work with a less rapid rate of combustion, a slower piston speed, and more expansively.

The goods engines were moderate in weight, had large cylinders and small wheels, and drew heavy train at a fair speed with a consumption of coal often amounting to 100lbs. or more per mile. On the Pennsylvania Central railroad, the standard type of this class of engine had ten wheels, of which six, each 4 feet six inches in diameter, were coupled. The whole weight of the engine was only 31⅛ tons, and of this but 23½ tons rested on the coupled wheels, available for adhesion. The cylinders were 18 inches in diameter, with a length of stroke of 22 inches. With 60lbs. mean effective pressure per square inch upon the pistons, these engines would exert a tractive force, less their own internal resistances of rather more than 3½ tons, or about one seventh their adhesion weight, although in starting a train, or in ascending a gradient, with 100lbs. pressure on the pistons, the steam tractive force would be 6 tons, equal to more than one-fourth of the adhesion weight, the efficiency of which would then be assisted, when necessary, by sand. Details of the performances, of some of these engines were next given. In one case, after allowing for gravity 8⅝lbs. per ton for a train, engine and tender included, of 1,040 tons weight, the total resistance would be 4 tons, and thus the work done on each mile was calculated to 24 H.P. exerted for one hour; and if the estimates could be trusted, the consumption of coal per H.P. per hour would not exceed from 4¼ lbs. to 5¼ lbs. The speed probably was not more than 15 miles an hour, corresponding to 360 H.P. The policy of American railway managers with respect to goods traffic, as it was also the policy of the managers of most of the French lines, was maximum loads at slow speeds, involving a minimum resistance per ton, and correspondingly a minimum working expenditure per ton.

No experiments upon the dynamical efficiency of American engines had been made, so far as the Author was aware; but he had run an experimental train on the Erie railway, over the whole length of the line and back, a total distance of nearly 900 miles. The same engine was employed throughout the run, occupying in all nearly three weeks, making an average for each week-day of about 50 miles. The results of these experiments appeared to show, that the resistance of bogie rolling stock, even under disadvantages, was less than that of English rolling stock as ascertained by the best authorities, and also that the ratio of adhesion to weight averaged considerably more in the States than in England. With respect to adhesion, as the surfaces in contact were identical with those on English railways—indeed the rails and tyres in general use in the States were commonly of English manufacture—and difference in this respect must be attributed partly to the influences of climate and partly to a better application of sand, when necessary to increase the bite upon the rails. The sand was dropped equally upon both rails, not in intermittent handfuls down a pipe on one side of the engine only, but by means of the hand gear and regulating valve since adopted on the North London railway. The experiments in question were, no doubt, influenced by the favourable circumstances of weather, and something was to be allowed also for the great length of train drawn, very long trains having a less tractive resistance per ton on a level than short ones, and something, possibly more than was commonly supposed, might have been due to the use of oil-tight axle-boxes, the saponaceous compound known as 'Railway Grease' being nowhere in use on railways in the States. Messrs. Guebhard and Dieudonuè's experiments, made in 1867, on the Eastern Railway of France, showed a considerable diminution in the resistance of oil-boxed rolling stock as compared with that fitted with grease-boxes.

Of the mechanical details of American locomotives, considered apart from the details already touched upon, much might be said. There were differences, and they were numerous, but they involved no important principles. The chilled cast-iron wheel, however, for engine and tender bogies, and especially for carriages and wagons, deserved mention. No wrought iron wheels, so far as the author could learn, were now employed in the States, unless in a few cases for engine driving-wheels; and wrought iron wheels, at first exclusively adopted, had been wholly abandoned on the Grand Trunk and the Great Western railways of Canada. The cast iron wheels were not only much cheaper, but they were more durable, and, if not safer, were at least equally safe. The wheels employed for passenger carriages were 2ft. 9in. in diameter, and weighed 5cwt. The bogie wheels of engines, tenders, and goods wagons were generally 2ft. 6in. in diameter, and varied in weight from 4cwt. to 4½cwt. They were cast of special mixtures of the best qualities of iron, the requisite conditions being great absolute strength to resist both sudden and progressive strains, and the property of taking a deep and uniform chill. But little of the cast iron employed for wheels had a tensile strength of less than 15 tons per square inch, and it broke with a fracture, almost suggestive of fibre, and of a dark gray colour, but when chilled of a silvery whiteness. The chilled wheels ran from two to six and even seven years, according to the traffic, before becoming so much worn as to require removal, representing a service of from 80,000 miles to 200,000 miles. Engine driving wheels of from 4ft. to 5ft. in diameter, had been cast with chilled faces, thus requiring no tyres, and chilled tyres, from 4ft. to 6ft. in diameter, and 3½in. thick, had been extensively and successfully employed at fair rates of speed, say 28 miles an hour.

Wood was almost exclusively employed as fuel, except upon two or three important lines in the coal districts, until within the last ten or twelve years. Iron fire-boxes and copper tubes were then generally adopted; but for burning coal, steel fire-boxes and iron tubes were now used. Of upwards of four hundred steel fire-boxes in the engines of the Pennsylvania Central railway, some had been in use for six years or more. The tubes were set without ferrules, and very little trouble, as the author was informed, was experienced either from leaking or cracking. It was worthy of observation, that the evil of 'furrowing,' by no means uncommon in this country, was unknown in the States, and no other explanation appeared available, than that the thinner iron employed there permitted of a certain elasticity in the structure of the boiler, sufficient to prevent the localisation or accumulation of bending or other strains at particular points, or rather upon particular *lines* of resistance.

What were now understood as steep, or exceptionally steep, gradients were rare in the States. Some instances of such were cited, and it was mentioned that, in July, 1836, one of Norris's engines, weighing 6tons 8½cwt., and drawing behind it, including tender, a load of 8 tons 11½cwt., ascended an incline near Philadelphia of 1 in 14, and 933 yards long, at an average speed of 15¾ miles an hour. The nominal weight on the driving wheels was 3½tons, but it was believed that a portion of the weight of the tender was made to bear upon the foot plate, thus increasing the adhesion.

With regard to the expense of maintenance, it was stated that the average cost of engine repairs in the States, exclusive of those renewals which amounted to building a new engine, might be taken as a maximum at 10 cents currency per train mile, equal to 3¾d. in coin. Of this, the absolute difference in the cost of labour and materials would account for nearly or quite 1d., leaving 2¾d. to 3d. as the cost at English prices. Again, the manner in which these repairs were conducted showed a want of system and organisation, and the shops were not fitted with some of the appliances considered essential in this country. Whatever economy in repairs might attach to the American engines was due, after allowing for the moderate working speed, to three causes only—viz., the use of the bogie, of chilled cast iron bogie wheels (which could be renewed at a cost of from £2 to £2 10s. each, after allowing for the value of the wheel taken out as old iron), and of steel or iron fire-boxes and iron tubes. About twelve or fifteen years ago, the average mileage of American engines, taking the full stock of the leading lines, was not above 15,000 miles yearly—now it was probably not far short of 20,000 miles, and on some lines it might be even more.

There remained the consideration of the carriage and wagon stock, with reference to its mechanical peculiarities and its commercial relation to traffic. The earlier American carriages were made upon the English model, but it was found, not only that a short wheel base was required for six chain and nine chain curves, but also that side buffers aggravated the difficulty. The bogie, already in use on the engines, was, therefore, adopted for the carriages, and it was soon discovered that the length of body could be considerably increased, and that the longer it was the steadier it became. But the long bodies precluded the use of side buffers, and so the central buffer with a loose coupling took their place. End doors afforded an obvious means of economy in the structure of the carriage, and left the whole depth of the body below the window sills available for any combination of trussing, most effective for carrying a comparatively long span. The end doors, with a continuous passage throughout the carriage, afforded obvious facilities for communication. The central passage passage required an additional width of carriage, and from 9ft. to 2ft. 6in. was a common outside width; while, in some cases, even on the narrow gauge, a width of more than 10ft. had been adopted. These widths allowed seats for four passengers across and for the longitudinal passage dividing the seats. The seats had reversible backs, so that the passenger might face either way, the carriages running in either direction without turning. It was undeniable that the seating was not so roomy and comfortable as in an English first-class carriage, and that, as compared with a second-class carriage, there was a certain loss of space. It was equally undeniable that such carriages could never answer for short traffic lines, where forty, fifty, or more passengers had to leave, and as many more to enter in a minute or a minute and a half. The long body, however, with end doors and platforms, possessed obvious mechanical advantages. Its length gave steadiness, and the depth below the window sills afforded ample opportunity for providing vertical stiffness without undue increase of weight. There were no cross partitions; there were but two doors where English carriages would require, for the same number of seats according to class, from twelve to twenty-six; there was much less sash and glazing, while there was at the same time more light; there was an important saving in respect of draw-springs, buffers, buffer-rods, and screw couplings, and there was every facility for applying brakes, as was always done in the States, to every wheel in the train, either from the platforms of the carriages themselves or from the engine. It was an advantage of the long body, were then alluded to, and a description was given of the oil-tight axle-box, as well as of Loughridge's and of Creamer's continuous brakes.

In comparing the cost of maintenance of American carriage and wagon stock with that on English lines, many considerations were to be regarded. To say that the cost, in 1867, on the 1612 miles of railway in the State of Massachusetts, for a train mileage of nearly ten million miles, was 6.55 cents, currency or about 2½d. coin, per train mile, did not permit of any accurate deductions. In the States, the average number of passengers continuously carried over the whole distance made by a train was generally one half greater than in England although the proportion of dead weight to live load was probably nearly as high as in this country; the speed was less, and there remained the fact that labour and nearly all materials were much dearer. On the other hand, there was a considerable saving in the use of chilled cast-iron wheels, such a thing as a wheel-turning lathe for carriage or wagon stock being unknown in the States; the maintenance of buffer and draw springs cost much less; the maintenance of the carriage bodies was cheaper, from their greater strength and simplicity of structure, and from the fact that there were no side doors to slam.

One objection to the use of chilled cast iron wheels, not referred to in the earlier portion of the paper, was that, being almost necessarily of the disc form, their weight increased in a ratio nearly as the square of the diameter, and thus the largest railway carriage wheels yet employed in the States were but 3ft., and this size was long ago discontinued in preference for 2ft. 9in. In the case of cast iron spoked wheels, the chill was less hard opposite the ends of the spokes than elsewhere, and thus they soon showed flat spots.

It might be said, in conclusion, that if American railway practice were in any or many respects more daring than that which prevailed in this country, failure, if not too often repeated, was regarded in the cousin country as a misfortune, where here, unless it proceeded from causes absolutely beyond prevision, it was rightly regarded as a fault, a misdemeanour, or even a crime.

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## SOCIETY OF ARTS.

### CANTOR LECTURES.

### "On the Aniline or Coal Tar Colours."

By W. H. Perkin, Esq., F.R.S.

### Lecture 1.

### *Coal Tar, Benzol, Nitrobenzol, Aniline, and Aniline Purple or Mauve.*

In this short course of lectures it is my desire to bring before you a somewhat condensed history of the artificial colouring matters, generally known as the "Coal Tar Colours." By this designation it is not meant to imply that colouring matters actually exist in coal tar, and may, therefore, be extracted from it, but that coal is the source of certain products which, when changed by various chemical processes, are capable of yielding coloured derivatives. You will thus perceive that it is important for us to consider the various means employed to obtain the raw materials before giving our attention to the colouring matters themselves. We will, therefore, at once proceed to the consideration of "coal tar;" its formation and constitution.

Coal tar consists of the oily fluid formed by the destructive distillation of coal, and is obtained as a secondary product in the manufacture of coal gas. Originally, coal tar was a great nuisance to the gas manufacturer, and it was often a problem to him what he should do with it. I need scarcely say that this state of things is now changed. In the gas works the coal is distilled in large retorts, sometimes 25ft. or 30ft. in length. They are made of fire-clay or iron, and several are arranged in one furnace, or oven, as it is usually termed. Each retort is fitted with an iron mouth-piece, from which a vertical tube rises, the mouth-piece also having a door fastened with a cross-bar and screw.

When in use these retorts are rapidly filled with coal by means of a proper scoop, and then the doors luted and fixed so as to be air-tight. Distillation commences immediately, as the retorts are constantly kept red hot. The gas and other products which form, pass up the front vertical pipe (connected with the mouth-piece), through a bend, and down into a long horizontal tube, called the "hydraulic main." Here most of the oily products condense, and as they accumulate pass on with the gas down the general main, and flow into a tank provided for their reception. These oily products constitute "coal tar." The coal gas, leaving this tar behind, passes on to the condensers, and deposits a second but smaller quantity of tar, and is then purified and stored in the gas-holders. The gas, however, does not interest us now.

I am here distilling some coal in a small glass retort, the beak of which is inserted into one of the openings of a three-necked receiver. The second opening is connected with the tube, so that the gaseous products may be examined, whilst the third and lower one is fitted to a small bottle, in which you see we have already obtained a quantity of an oily fluid. This is our coal tar.

Having now seen how coal tar is produced, we will consider of what it consists. Coal tar is by no means a definite body, but contains a great number of different substances, as a glance at the following table will show:—

Table I.—Products of the Distillation of Coal.

| Name. | Formula. | Boiling point Centigrade. |
|---|---|---|
| Hydrogen | H H | ... |
| Marsh gas (hydride of methyl) | $(CH_3)H$ | ... |
| Hydride of hexyl | $(C_6H_{13})H$ | 65 |
| Hydride of octyl | $(C_8H_{17})H$ | 106 |
| Hydride of decyl | $(C_{10}H_{21})H$ | 158 |
| Olefiant gas (ethylene) | $C_2H_4$ | ... |
| Propylene (tritylene) | $C_3H_6$ | ... |
| Caproylene (hexylene) | $C_6H_{12}$ | 55 |
| Œnanthylene (heptylene) | $C_7H_{14}$ | 99 |
| Paraffin | $C_n H_n$ | ... |
| Acetylene | $C_2H_2$ | ... |
| Benzol | $C_6H_6$ | 80·8 |
| Parabenzol | $C_6H_6$ | 97·5 |
| Toluol | $C_7H_8$ | 110 |
| Xylol | $C_8H_{10}$ | 139 |
| Cumol | $C_9H_{12}$ | 148·4 |
| Cymol | $C_{10}H_{14}$ | 170·7 |
| Napthalene | $C_{10}H_8$ | 212 |
| Paranapthalene (anthracene) | $C_{14}H_{10}$ | ... |
| Chrysen | $C_6H_4$ | ... |
| Pyren | $C_{15}H_4$ | ... |
| Water | $\left\{\begin{matrix}H\\H\end{matrix}\right\}O$ | 100 |
| Hydrosulphuric acid | $\left\{\begin{matrix}H\\H\end{matrix}\right\}S$ | ... |
| Hydrosulphocyanic acid | $\left\{\begin{matrix}H\\(CN)\end{matrix}\right\}S$ | ... |
| Carbonic oxide | $CO$ | ... |
| Carbonic anhydride | $CO_2$ | ... |
| Bisulphide of Carbon | $CS_2$ | 47 |
| Sulphurous anhydride | $SO_2$ | —10 |
| Acetic acid | $\left\{\begin{matrix}H\\C_2H_3O\end{matrix}\right\}O$ | 120 |
| Carbolic acid (phenol) | $\left\{\begin{matrix}H\\(C_6H_5)\end{matrix}\right\}O$ | 188 |
| Cresylic acid (cresol) | $\left\{\begin{matrix}H\\(C_7H_7)\end{matrix}\right\}O$ | 203 |
| Phlorylic alcohol (phlorol) | $\left\{\begin{matrix}H\\(C_8H_9)\end{matrix}\right\}O$ | ... |
| Rosolic acid | $C_{12}H_{12}O_3$ | ... |
| Brunolic acid | ......... | ... |
| Ammonia | $\left\{\begin{matrix}H\\H\\H\end{matrix}\right\}N$ | —33 |
| Aniline | $\left\{\begin{matrix}(C_6H_5)\\H\\H\end{matrix}\right\}N$ | 182 |
| Pyridine | $(C_5H_5)'''N$ | 115 |
| Picoline | $(C_6H_7)'''N$ | 134 |

| Name. | Formula. | Boiling point Centigrade. |
|---|---|---|
| Lutidine | $(C_7H_9)'''N$ | 154 |
| Collidine | $(C_8H_{11})'''N$ | 170 |
| Parvoline | $(C_9H_{13})'''N$ | 188 |
| Coridine | $(C_{10}H_{15})'''N$ | 211 |
| Rubidine | $(C_{11}H_{17})'''N$ | 230 |
| Viridine | $(C_{12}H_{19})'''N$ | 251 |
| Leucoline | $(C_9H_7)'''N$ | 235 |
| Lepidine | $(C_{10}H_9)'''N$ | 260 |
| Cryptidine | $(C_{11}H_{11})'''N$ | 256 |
| Pyrrol | $(C_4H_5)'''N$ | 133 |
| Hydrocyanic acid | HCN | 26·5 |

This list, however, does not indicate all the constituents of coal tar, but only those which chemists have up to the present time succeeded in separating from it; moreover, when we consider how greatly coal differs in composition, and also that the products vary according to the temperature to which the coal has been submitted, it is evident that coal tar must be an almost endless source of chemical products. Many would perhaps consider this list a perfectly harmless jumble of names impossible to impress upon the memory; but fortunately, chemists are able to classify their products, so that this formidable array of substances may be grouped under three or four different heads only, and, therefore, their their relationship being once understood, little difficulty is experienced in remembering their names.

Amongst these products, and at the lower part of this table, you will observe a substance called "aniline." This substance is of great interest to us, being one of the principal sources of the coal-tar colours. Aniline was discovered by Unverdorben, in 1826, amongst the products of the distillation of indigo, and from its property of forming crystalline compounds with acids was called "crystalline." Afterwards Runge obtained it from the distillation of coal, and, because it gave a blue colouration with a solution of chloride of lime, called it "kyanol," or blue oil. Fritzsche, still later, obtained aniline by the distillation of indigo with hydrate of potassium, and gave it its present name, derived from anil, the Portuguese for indigo. About this time Zinin discovered a remarkable reaction, by which he obtained aniline from a substance called nitrobenzol; he called it, however, benzidam. The products obtained by different chemists were not at first known to be identical; and it was not until Dr. Hofmann investigated the subject that they were all shown to be the same body, aniline.

Zinin's process for the conversion of nitrobenzol into aniline consisted in treating the nitrobenzol with an alcoholic solution of sulphide of ammonium; This was greatly improved upon by Bechamp, who employed a mixture of finely-divided iron and acetic acid, in place of sulphide of ammonium.

This is a brief sketch of the history of aniline up to the time of the discovery of the mauve dye; it was then purely a laboratory product, and was prepared in very small quantities at the time, and only when required for scientific research. Chemists have always been desirous of producing natural organic bodies artificially, and have in many instances been successful. It was while trying to solve one of these questions that I discovered the "mauve." I was endeavouring to convert an artificial base into the natural alcaloid quinine, but my experiment, instead of yielding the colourless quinine, gave a reddish powder. With a desire to understand this peculiar result, a different base of more simple construction was selected, viz., aniline, and in this case I obtained a perfectly black product; this was purified and dried, and when digested with spirits of wine gave the mauve dye.

You will perceive that this discovery did not in any way originate from a desire to produce a colouring matter, as is sometimes stated, but in experiments of a purely theoretical nature.

After showing this colouring matter to several friends, I was advised to consider the possibility of manufacturing it upon the large scale, and was, eventually, induced to make the experiment, though, I must confess, not without considerable fear of the result, especially as my chemical advisers set before me anything but encouraging prospects. In starting this manufacture, the first difficulty was to decide upon the source from which aniline could be obtained at a sufficiently low price. It was at once evident that indigo was far too costly a product for this purpose. Attention was therefore directed to the extraction of aniline from coal-tar, but after very numerous experiments, it was found that the difficulty of purifying it was so great, that it was not practicable to prepare it a reasonable price from this product. There was, therefore, but one source left, namely, nitrobenzol; but to prepare aniline from this body necessitated the establishment of a new manufacture; nitrobenzol at that time not being a commercial artical, and although it could be produced in small quantities without much difficulty, yet when tons were required at a limited cost many obstacles presented themselves.

Having spoken of nitrobenzol, it will be necessary, before proceeding further, to tell you something of the body it is prepared from, and also how it is made in quantity. Nitrobenzol is produced from a derivative of coal-tar called benzol—you will see it mentioned in the list of coal-tar products. It is composed exclusively of carbon and hydrogen, and is therefore called a hydro-carbon.

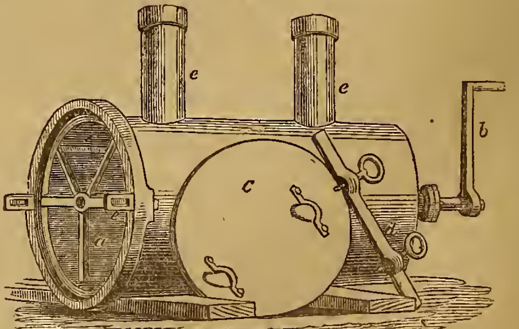
Benzol was discovered by Faraday, in 1825, one year before aniline by Unverdorben. Its existence in coal-tar was first pointed out by Dr. Hofmann in 1845 and afterwards Mansfield showed that an almost unlimited supply might be obtained from this source. Benzol is a volatile oil boiling at a temperature of 80·8° C., nearly twenty degrees lower than water, and is also very inflammable, burning with a smoky flame. When ignited it cannot be extinguished by water, as it floats upon its surface. Its vapour, when mixed with air, is explosive. It is also very dense. This I can easily show you by decanting a small quantity of benzol vapour several times from one vessel into another and then igniting it. Instances have been known, when distilling benzol in large quantities, and some leak in the apparatus has occurred, so that its vapour has escaped, that it has run along the ground, and been ignited by a furnace situated thirty or forty feet distant, and instantly run back to the apparatus. To illustrate this I will pour some benzol vapour into the top of a slightly inclined trough, fourteen feet long, at the lower end of which is placed a lamp. The vapour will be seen to run gradually down till it reaches the lamp, where it ignites and instantly rushes back to the top of the trough. One of the most remarkable properties of benzol is, that when cooled down to nearly the freezing point of water it solidifies into a beautiful crystalline mass. This property of benzol is sometimes taken advantage of when it is required in a very pure state, as the impurities which accompany it are fluid, and do not freeze when cooled with ice.

Benzol is often sold under the name of benzine collas, for the purpose of removing grease from wearing apparel. But let us consider how benzol is separated from the great number of products with which it is associated in coal-tar. The first operation consists in distilling the coal-tar just as it comes from the gas-works, in large stills, holding one or two thousand gallons each; these are often made of old steam-boilers; at first very volatile and light oily products come over, and are collected until their density increases to such an extent that they no longer float upon water. These constitute crude coal-tar naphtha. The distillation is then carried on, and heavy, or, as they are technically termed, "dead" oils, are collected, a residue of common pitch being left in the still. This pitch is generally run out, and cast into blocks; but sometimes the distillation is carried on after the dead oils have been obtained, when a mixture of solid oily products distils, nothing but a kind of cake being left behind. These latter substances, however, do not interest us now.

The light oil, or crude coal tar naphtha, is then purified by one or two alternate distillations with steam and treatments with concentrated sulphuric acid. It is thus rendered a colourless fluid. Thus purified, coal tar naphtha contains, besides benzol, at least four or five other bodies. These, however, mostly differ from benzol in being less volatile; therefore, the naphtha is again distilled, the first, or more volatile, portions only being collected for benzol. By repeating this process of fractional distillation several times commercial benzol is obtained. Some manufacturers employ stills of a peculiar construction, which enables them to obtain a good product by a smaller number of distillations. Benzol, when treated with fuming nitric acid or aquafortis, undergoes a remarkable change. At first the two fluids mix and become of a dark brown colour and slightly warm, in the course of a few moments red fumes appear, and the mixture enters into ebullition. During this violent action the colour of the liquid becomes lighter and ultimately changes to orange. If water be now added to this product, the benzol, which is such a light body, will be seen to have completely changed into a dense yellow oil sinking in water. This oil is nitro-benzol. Nitro-benzol was discovered in 1834, by Mitscherlich. It solidifies into a crystalline mass at a temperature of about 3° C.; its odour is like that of the oil of bitter almonds, and before the introduction of coal tar colours it was made in small quantities, and sold under the name of essence de Myrbane, for the purpose of scenting soap.

From the energy with which benzol is attacked by fuming nitric acid, nitrobenzol at first appeared to be a most difficult product to manufacture on the large scale, and this difficulty seemed the greater when it was found necessary that it should be made at a moderate cost. Moreover, at the time I am now referring to, fuming nitric acid, sp. gr. 1.5, could not be obtained in the market, or only at such a cost as almost to preclude its use. Under these circumstances, two mixtures were experimented with instead of the nitric acid in a very concentrated condition. The first was a mixture of nitrate of sodium and sulphuric acid, the second a mixture of ordinary nitric acid, sp. gr. 1.3, and sulphuric acid. The mixture of sulphuric acid and nitrate of sodium was preferred, and employed on the large scale.

Fig. 1.



The first apparatus used in the manufacture of nitro-benzol, for the preparation of anniline for the mauve dye, is shown in Fig. 1. It consisted of a large cast-iron cylinder, *a*, fitted with a stirrer, *b*, and closed with a door, *c*, fastened by a cross-bar and screw, *d*. This cylinder was capable of holding between thirty and forty gallons. It was provided with two necks *e e*, one for the introduction of the benzol and sulphuric acid, which were supplied through a syphon tube; the other for the exit of nitrous fumes. This last was connected with an earthenware worm, to condense any benzol which might be violatised by the heat of the re-action. The nitrate of sodium was always introduced into the cylinder before the door was fastened up and luted. Until the preparation of nitro-benzol was understood, there was a great amount of uncertainty in its manufacture, and several explosions occurred, but fortunately without causing any injury to the workmen attending the apparatus. These explosions originated generally from the liberation of too much nitric acid from the nitrate of sodium, by the sulphuric acid, before the formation of nitro-benzol had begun so that when it started, the chemical action set in with such energy that an explosion ensued. After a few of these unpleasant occurrences, however, sufficient experience was obtained to get the manufacture under control. Apparatus of a much more extensive character has since been substituted for the cylinders. In Figs. 2 and 3 you get a view of the apparatus now used in England for the manufacture of nitro-benzol.

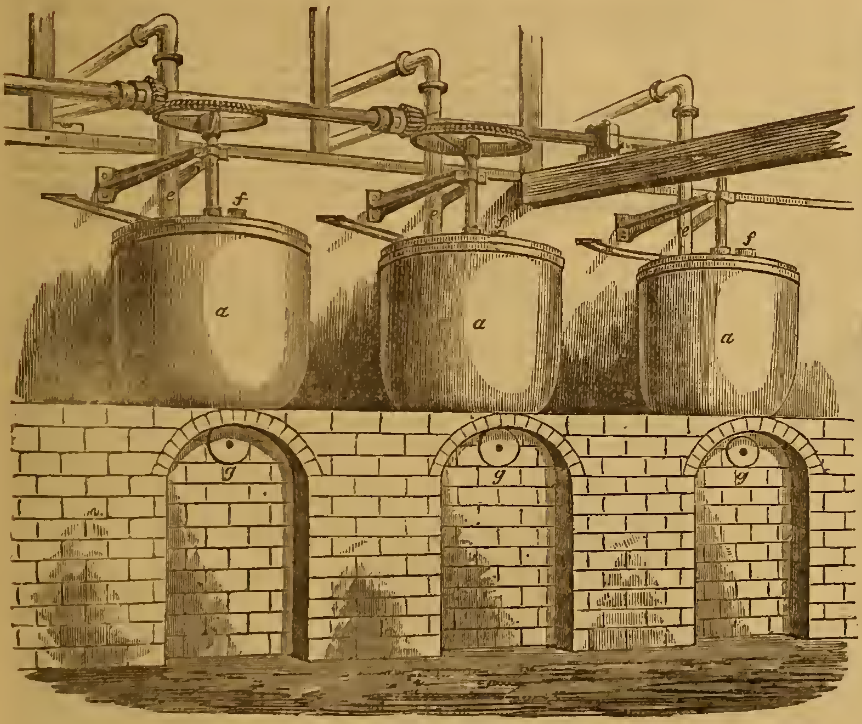


Fig. 2.

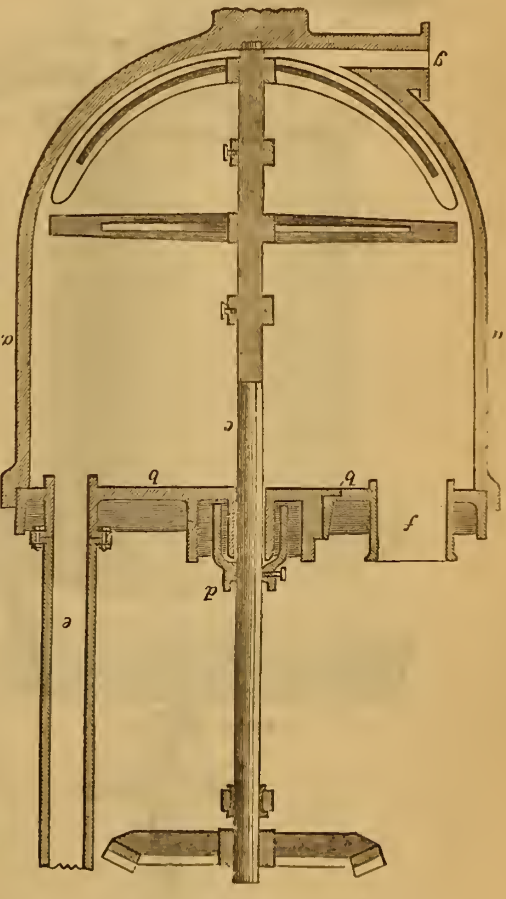


Fig. 3.

This apparatus consists of large cast-iron pots, *a a a*, about 4ft. 6in. deep, and 4ft. 6in. wide; they are arranged in rows, and provided with stirrers, worked from a shafting by means of bevel wheels. This arrangement will be seen from the section, Fig. 3; the covers of these vessels are also made of cast-iron, and are in two pieces *b′ b* (Fig. 3) of unequal size, provided with a tall rim, and so arranged that cold water may be kept circulating over their surface; this assists in condensing the benzol, which would otherwise distil away by the heat of the re-action. Through the larger half of the cover the spindle of the stirrer, *c* passes, and on account of the difficulty of keeping a stuffing box in order when using the powerful chemicals necessary in this manufacture, a kind of water-joint has been substituted. It is necessary that it should be deep and rather capacious, as seen at *d*. Instead of filling this joint with water, which would soon destroy the apparatus, the joint is filled with nitro-benzol; a cast-iron tube *e*, passes through the lid to carry away nitrous fumes; this is also cooled, so as to condense any benzol vapour which may have escaped the cooling action of the lid; small pipes are introduced through another opening for the purpose of supplying the necessary chemicals. Besides these, there is a large opening, *f*, in the smaller half of the lid, for the purpose of introducing any of the products which may be added in large quantities at a time. At the bottom of these large vessels are openings for running out the finished product.

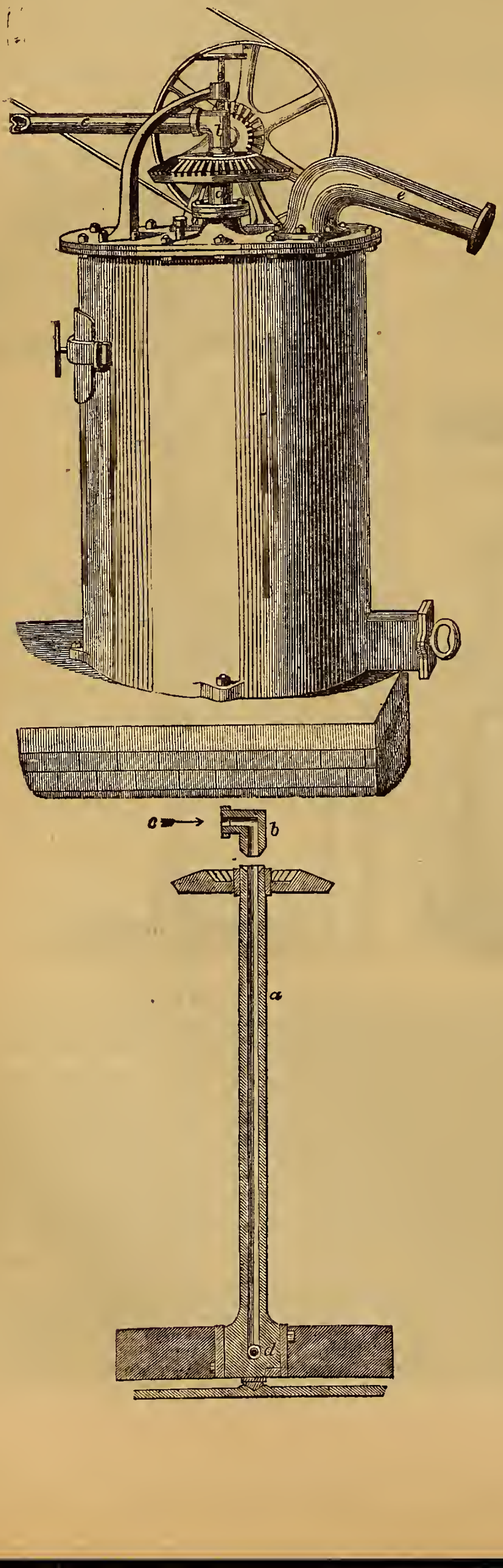
The process of preparing nitro-benzol with a mixture of sulphuric acid and nitrate of sodium in place of nitric acid, may be carried on very well in this apparatus, provided sufficient sulphuric acid be employed to produce an acid sulphate of sodium, as this will be found quite fluid at the close of the operation, and can be freely run out at the small outlet. A mixture of strong nitric acid and sulphuric acid is now usually employed for the conversion of benzol into nitro-benzol. In working by this latter method the entire charge of benzol is first introduced though the large opening in the lid; this is then closed and the stirrer set moving; the nitric and sulphuric acids are then cautiously run in through the small pipes, care being taken not to add too much nitric acid, until the red fumes begin to appear. After all the charge of acids has been added, and the reaction has perfectly ceased, the product is drawn off. At first a mixture of sulphuric and nitric acids runs out, and then the nitrobenzol; this is collected separately and purified, first by agitation with water, and then rendered perfectly neutral by means of a dilute solution of soda. Should it contain any unconverted benzol this may be distilled off by means of steam. On the Continent manufacturers do not appear to have succeeded well in manufacturing nitrobenzol; when it first became a commercial article, their difficulty appears to have arisen from the fact that they experimented in earthenware vessels, which are both dangerous and unsuitable, and it was not until information was obtained from England, I believe, that they were able to produce this body at a moderate price.

We will now pass on to the processes for converting nitrobenzol into aniline. I have already mentioned that Zinin was the first who discovered that nitrobenzol could be converted into aniline, or, as he termed it, benzidam. He process consisted in treating an alcoholic solution of nitrobenzol with ammonia and sulphuretted hydrogen; but, although the discovery of this process was one of great importance from many points of view, still it was very tedious. Bechamp, however, found that by employing a mixture of acetic acid and finely divided iron instead of ammonia and sulphuretted hydrogen, the nitrobenzol was very rapidly converted into aniline, and this process as been found the best yet proposed for manufacturing aniline in large quantities. Many other re-agents have been suggested, as arsenite of sodium, powdered zinc, &c., but none of them have been found so advantageous as iron and acetic acid.

In carrying out Bechamp's process, cylinders like those used for nitrobenzol (Fig. 1) were originally employed. The cylinder was set in brickwork, and heated by means of a small furnace, iron borings were first introduced, and the door fixed in its place air-tight. One neck was connected to the upper extremity of a cast-iron worm by means of a pipe called an adapter; the second neck being fitted with a syphon-tube, for the introduction of the nitrobenzol and acetic acid. In working on the large scale it is necessary to add the nitrobenzol and acetic acid in small quantities at a time, otherwise the reaction is so violent as to almost burst the apparatus: by working carefully, however, there is no need to fear any difficulties, especially if the stirrer is well used. By the time all the charge has been introduced, a quantity of fluid will have distilled over; this is returned into the cylinder and the fire lit, and the aniline distilled off.

The principal change which has taken place in this process consists in using high pressure or superheated steam for the distillation instead of fire, and working the apparatus by means of a steam-engine instead of by hand. In Fig. 4 is shown a sketch of the apparatus now generally employed for the preparation of aniline.

Fig. 4.



You will observe that the stirrer, which is worked by bevel wheels, has a hollow shaft or spindle, *a*, as seen in the section. This is ground to an elbow, *b*, connected to the steam main, *c*, and held down by a screw, so that when the steam is turned on, it passes through the hollow elbow down the shaft, and then blows out at the bottom, *d*, among the products; and in this manner the aniline is volatilized, and passes with the steam through the neck, *e*, and is condensed by a worm, not shown in this drawing. Aniline thus obtained is generally redistilled, and sometimes with a little lime or caustic soda, for the purpose of decomposing a body called acetanilide, which is often produced in the manufacture of aniline, especially if the operation is conducted over a fire instead of with steam.

Commercial aniline generally appears of a pale sherry colour; when chemically pure, it is colourless, but if kept long it becomes quite brown. It possesses a peculiar odour, which is slightly vinous when the aniline is pure. It burns with a smoky flame, but it is not very inflammable; its boiling point is 182° C. One of its most characteristic re-actions is its power of producing a blue or blue violet colouration with chloride of lime, to which I shall again have occasion to refer. Aniline differs entirely from benzol and nitrobenzol, being perfectly soluble in dilute acids. This is owing to its being an organic base, and forming compounds with acids. Thus with hydrochloric acid, it forms hydrochlorate of aniline; with sulphuric acid, sulphate of aniline, &c.

We will now, in a very rapid and general way, glance at the chemical changes which take place in connecting benzol with nitrobenzol and aniline.

Benzol, as I have already stated, is a hydrocarbon, *i.e.*, a body composed of hydrogen and carbon only; it is represented by

$$C_6\,H_6$$

This is treated with nitric acid, which contains.

$$H\,N\,O_3$$

The nitric acid acts upon the benzol and introduces its nitrogen and part of its oxygen, at the same time removing hydrogen and forming water.

$$\underbrace{H\ N\ O_3}_{\text{Nitric Acid.}} + \underbrace{C_6\,H_6}_{\text{Benzol.}} = \underbrace{C_6\,H_5\,N\,O_2}_{\text{Nitrobenzol.}} + \underbrace{H_2\,O}_{\text{Water.}}$$

Nitrobenzol, when treated with iron and acetic acid, is converted into aniline by the influence of hydrogen gas, in what is termed the nascent state, or the peculiar condition in which it is when being liberated from a compound.

This hydrogen unites with the oxygen of nitrobenzol and removes it as water, and at the same time two atoms of hydrogen combine with the deoxygenated nitrobenzol, forming aniline.

$$\underbrace{C_6\,H_5\,N\,O^2}_{\text{Nitrobenzol.}} + H_6 = \underbrace{C_6\,H_7\,N}_{\text{Aniline.}} + 2\,H_2\,O$$

Having now seen the various operations which require to be performed for the production of aniline from coal tar, we are prepared for the consideration of its coloured derivatives. We will, therefore, commence at once with the first of the coal tar colours, "the mauve dye." I have already given you the history of its discovery; I will now tell you how it is made.

First of all aniline and sulphuric acid, in the proper proportions for the formation of sulphate of aniline, are mixed in a large vat with water, and boiled until perfectly dissolved. Bichromate of potassium is then dissolved in a second large vat. These two solutions, when cold, are mixed in a third and still larger vessel, and allowed to stand one or two days. In this way a large quantity of a fine black precipitate is formed; this is collected upon shallow filters, well washed with water, and then dried. When dry it is a most unpromising sooty-black powder, and contains various products besides the mauve; the most troublesome of these is a brown, resinous product, soluble in most of the solvents of the colouring matter itself.

At first this resinous substance was removed by digestion with coal tar naphtha previously to the extraction of the colouring matter, which was afterwards effected with methylated spirits of wine, and the solution thus obtained when distilled left the mauve as a fusible bronze-coloured mass.

When digesting the black precipitate with naptha or strong spirits of wine, the operation had to be performed in closed vessels under pressure or in connection with a condensing arrangement, otherwise large quantities of these valuable solvents would have been lost, and great difficulty was experienced in getting apparatus perfectly tight, on account of the "searching" character of these fluids. Substitutes had also to be found for the ordinary materials employed by engineers for making good manhole joints, and a number of other matters which are apparently of but small importance, but it is remarkable the amount of difficulty and annoyance they caused. The method of extraction has, however, been materially improved upon by substituting dilute methylated spirits of wine for strong, as this weaker spirit dissolves only a small quantity of resinous matter but all the colouring matter, so that the digestion with coal tar naphtha is now found unnecessary.

The solution of the colouring matter in dilute spirit is placed in a still and the spirit distilled off, the colouring matter remaining behind in aqueous solution; this is filtered and then precipitated with caustic soda. It is afterwards collected on a filter, washed with water, and drained until of a thick pasty consistence, and, if necessary, dried.

The solid mauve dissolves very freely in spirits of wine, forming an intensely coloured solution; it is also soluble to a small extent in water, but the aqueous solution on cooling forms a kind of jelly.

The formation of the mauve or aniline purple by the action of bichromate of potassium upon sulphate of aniline is a process of oxidation, and since the publication of the original specification at the Patent Office a great number of patents have been taken out for the preparation of this colouring matter, in which the bichromate has been replaced by other oxidizing agents, as peroxide of manganese, chloride of copper, &c.; but I need not make any special remarks upon these various processes, as experience has shown that bichromate of potassium and a salt of aniline, the reagents first proposed possess advantages over all others, and are now nearly universally employed for the preparation of aniline purple. The next best process appears to be that of Dale and Caro, in which chloride of copper is employed.

The affinity of aniline purple for silk or wool is very remarkable, and if I take some wool and pass it through a solution of mauve, you will see how rapidly it absorbs it, even from a very dilute solution. Aniline purple is sent into the market in three different conditions, in paste, in solution, and in crystals; but the latter are very rarely employed, as they are very expensive and do not offer corresponding advantages to the consumer.

The mauve is the most permanent coal-tar purple known, especially with respect to its power of resisting the action of light.

I will now endeavour to give you some idea of the approximate amount of the various products we have considered obtainable from 100lbs. of coal, and for this purpose I have arranged them in the following table with their respective weights :—

| | lbs. | ozs. |
|---|---|---|
| Coal | 100 | 0 |
| Coal-tar | 10 | 12 |
| Coal-tar naphtha | 0 | 8½ |
| Benzol | 0 | 2¾ |
| Nitrobenzol | 0 | 4¼ |
| Aniline | 0 | 2¼ |
| Mauve | 0 | 0¼ |

You see the smallness of the amount of colouring matter obtainable from coal or coal tar; but there is fortunately one thing which, to some extent, compensates for this, and that is the wonderful intensity of this colouring matter. I will illustrate this remarkable fact. I have here a large carboy containing nine gallons of water, and will now add to this a solution containing one grain of mauve, and illuminate the liquid with the magnesium lamp, and you see the single grain has coloured this large bulk of water. A gallon of water contains 70,000 grains, therefore nine gallons contain 630,000 grains. This solution, then, contains only one part of mauve to 630,000 of water.

I have now shown you the manifold operations which have to be performed before we can derive the mauve from coal tar, and have also mentioned a few of the obstacles which had to be overcome before its manufacture on the large scale could be accomplished. We have thus laid the ground work of our subject, and in our next lecture I hope to tell you a little more about mauve, and then give an account of the many other colouring matters of which it may be considered the parent.

## Lecture II.

You will remember that in my last lecture we went over all the various steps between coal and colour. We saw how coal tar was produced from coal; how coal tar, naphtha, and benzol were separated from coal tar: how nitrobenzol and aniline were made from benzol, and concluded with an account of the preparation of aniline purple, or mauve from aniline. We will now proceed to the study of some of the most remarkable properties of aniline purple.

This colouring matter is sometimes supplied to consumers in a pure and beautifully crystalline condition. This product is found to be a salt of a compound, chemically termed an organic base. This base has been called "mauveine," it is composed exclusively of carbon, hydrogen, and nitrogen, in the following proportions :—

$$C_{27}H_{24}N_4$$

Mauveine, although the base of aniline purple, when in solution is not of a purple but of a dull violet shade, and in the solid state is a nearly black crystalline powder. The moment, however, mauveine is brought in contact with an acid so as to form a salt, its solution changes to a purple colour. This takes place even with that feeble acid carbonic. I have here a dilute solution of mauveine; you will observe the dull violet colour it possesses, but if my assistant only breathes through it a few moments the carbonic acid of his breath will combine with it, and it will acquire the ordinary colour of aniline purple.

Mauveine is a most powerful chemical body, and will easily decompose ammoniacal salts. This may be readily seen if some mauveine be heated with chloride of ammonium and a little water, when an abundance of ammonia gas will be evolved, which can be distinguished not only by its odour, but by the white fumes it produces with hydrochloric acid.

The salts of mauveine are beautifully crystalline, and possess a splendid green metallic lustre. The crystallised commercial product consists of the acetate. Mauveine possesses one of the peculiar properties of indigo. Indigo, when treated with reducing agents, such as a mixture of sulphate of iron and lime, is rendered nearly colourless and soluble, but this colourless indigo, when subjected to the oxidising influence of the atmosphere, rapidly becomes blue again. I here refer to the indigo vat so much used by dyers Mauveine, when treated in a similar manner, is also nearly decolourised, changing to a pale brownish yellow fluid, but the moment this is exposed to the air it assumes its original colour far more quickly than indigo. This remarkable fact may be strikingly illustrated by boiling an alcoholic solution of salt of mauveine with a few strips of zinc in a sealed tube from which the air has been previously removed. The dark purple solution will gradually lose its colour, and change to a very pale-yellowish brown shade.

I have a tube containing some aniline purple decolourised in this manner, and now if I open it, the air rushes in and the solution instantly assumes the ordinary purple colour.

Ordinary indigo is quite insoluble in water, and, therefore, its property of becoming soluble, as well as colourless, when treated with reducing agents, is of great practical value, as the dyer, by immersing his goods in this solution of indigo, and then exposing them to the oxidising influence of the air, gets the colouring matter firmly fixed in the the fibre of his materials. But as the mauve is always soluble in water, this property has not been found of any practical value.

Aniline purple, when introduced as a dye, being the first colour of its kind, had to encounter many prejudices, and, on account of its peculiar nature, required the adoption of new or modified processes for its application. These difficulties, however, once overcome, its progress was very rapid. At first it was principally employed by the silk dyer and printer, its application to silk being comparatively easy, but it was not used by the calico-printer till a few years afterwards.

I distinctly remember, the first time I induced a calico-printer to make trials of this colour, that the only report I obtained was that it was too dear, and it was not until nearly two years afterwards, when French printers put aniline purple into their patterns, that it began to interest British printers.

It will be seen that to introduce a new coal-tar colour after the mauve was a comparatively simple matter. The difficulty in the manufacture of all the raw materials had been overcome, as well as the obstacles in the way of the practical applications of an aniline colour to the arts.

We will now turn our attention to a colouring matter which has often been confounded with aniline purple. I have designated it as "Runge's blue," as it was first observed by Runge. I have mentioned that Runge, when he first obtained aniline, termed it "kyanol," or blue oil, on account of the blue-coloured solution it gave with chloride of lime.

After discovering the mauve, I naturally made experiments with this coloured product of Runge's, to see if it contained aniline purple, but my experiments answered the inquiry in the negative. A few years afterwards, however, I was puzzled by finding that French manufacturers were beginning to produce aniline purple by the agency of chloride of lime and a salt of aniline; being much occupied at that time, I was unable to look carefully into the matter; and it was not until investigating these apparently opposite results a short time since that I was able to understand them. I will perform Runge's experiments, and for that purpose will take a solution of hydrochlorate of aniline, and add to it a very dilute solution of chloride of lime (taking care not to add too much.) The solution is now changing, and getting slightly opaque; by daylight it has an appearance like indigo, but if I render it clear by the addition of alcohol. and place it before the magnesium lamp, it is seen to be of a brilliant colour, and nearly pure blue, quite unlike aniline purple.

I have lately succeeded in obtaining this blue product in the solid condition, by treating a solution of hydrochlorate of aniline with a dilute solution of chloride of lime, and precipitating the resulting colouring matter with common salt; it is thus obtained in an impure condition, and may be collected upon a filter; by treatment with cold ether or benzol, a large quantity of brown impurities are separated, the colouring matter being left in the solid condition. This substance dissolves in alcohol, forming a nearly pure blue solution, and is capable of dyeing silk a blue or blue-violet colour.

An alcoholic solution of Runge's blue behaves with caustic potash quite differently to aniline purple, it being entirely different, both in colour and chemical properties. But as this colouring matter is produced by oxidising hydrochlorate of aniline with chloride of lime, how is it that manufacturers have succeeded in preparing aniline purple with the same re-agents? This question I find is very easy to answer; the manufacturer has gone a step further and boiled his product. Now, if I take a piece of silk dyed with Runges's blue, and, instead of boiling it, which would wet it, and make it difficult to manipulate, do that which is equivalent—steam it—a very remarkable change takes place—Runge's blue being changed into the mauve. So, here we have cleared up the mystery, and find that by the action of chloride of lime on hydrochlorate of aniline, we first get Runge's blue, and then, by heating this blue, we change it into mauve. Runge's blue is a very unstable body, and of no practical value, its alcoholic solution changing into mauve in a day or two. This change takes place directly by boiling.

We must now pass on to another colouring matter, in name well-known to all of you, I mean magenta, also called roseine, fuchsine, aniline red, and various other names. The discovery of this body and its manufacture were strangely dependent upon the source which had been selected for the preparation of aniline for the mauve. Had the aniline contained in coal tar, or the aniline obtained from indigo, been employed for the preparation of the mauve, instead of that prepared from commercial benzol, magenta and its train of coloured derivatives would in all probability have remained unknown to this present day, from the simple fact that magenta cannot be produced from pure aniline, a second body being also required.

You will observe, by reference to the table of coal tar products, that next to benzol there is a substance named toluol, a substance having a boiling point not very much above that of benzol. On this account toluol is always contained in commercial benzol, and possesses most of its properties. With nitric acid it forms nitrotoluol, very similar to nitrobenzol; with iron and acetic acid it is converted into a base, toluidine, very similar to aniline, except that it is solid instead of solid instead of liquid, when pure. Therefore, aniline prepared from commercial benzol always contains a little toluidine, and this is the second body requisite for the formation of magenta.

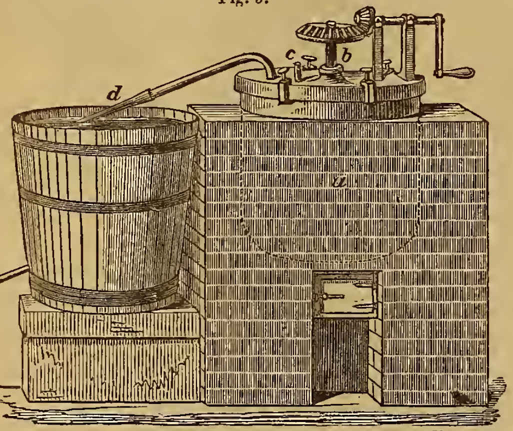
An apparatus for the fractional distillation of coal tar naphtha has been devised, so that its constituents may be almost completely separated from each other, and thus pure benzol or pure toluol may be obtained. Having obtained these hydrocarbons, pure aniline and pure toluidine may be prepared and then mixed in the most suitable proportions for manufacturing magenta. This process is not very generally employed, however, but the quality of the mixture of aniline and toluidine is determined by distillation, noting the quantities which come over at different temperatures. The necessity of toluidine as well as aniline for the production of magenta was discovered by Dr. Hofmann, who found that it could not be produced by perfectly pure aniline, nor perfectly pure toluidine, but that a mixture of these two bases yielded it in quantity

Magenta was apparently first observed by Natanson, in 1856, when examining the action of chloride of ethylene on aniline, and afterwards by Dr. Hofmann, in 1858, when studying the action of tetrachloride of carbon on aniline, but industrially the discovery of magenta was made by M. Virgnin, of Lyons, in 1859, three years after the mauve. M. Virguin's process consisted in treating commercial aniline with a fuming liquid. called tetrachloride of tin, and was first carried out by Messrs. Renard Brothers, of Lyons. Since 1859 patents have been taken out for the production of this colouring matter with aniline, and almost all chemicals known, whether capable or incapable of forming magenta. I may mention one process which was extensively employed, and is still used to some extent in Germany, and that is the method of making magenta with commercial aniline and nitrate of mercury. With care this process works very well, and the colouring matter produced is of good quality. When first introduced, magenta prepared by this method was not purified, but sent into the market in a crude form, so that before using it the dyer had to extract it with water. In the preparation of magenta by this process, all the mercury of the nitrate of mercury employed is recovered in the metallic state, but although this process may possess some advantages, yet the use of mercury salts is most undesirable, on account of their fearfully deleterious influence upon the workmen.

The process, which has almost superseded all others, is that for the use of arsenic acid, as proposed by Medlock, and patented by him in January 1860. This patent is notorious for the amount of litigation it has caused, showing that a patentee should not only be a discoverer but a lawyer, and even more, and able to discover precisely how much to claim and disclaim in his patent, and also to arrange his specification so that the intellects of the whole world may not be able to discover a single flaw in his description; and it is a common misfortune to inventors who wish to thoroughly protect themselves, to find that they have claimed too much.

The manufacture of magenta, as now carried on, is a very simple process; *it* is conducted in an apparatus somewhat similar to that represented by Fig. 5.

Fig. 5.



This apparatus consists of a large iron pot, *a*, about 4ft. diameter, set in a furnace of brick-work; it is provided with a stirrer, *b*, worked by hand. All the gearing for this stirrer is fixed to the lid, so that stirrer, lid, and all may be lifted away by means of a crane, or other suitable apparatus. There is also a bent tube fixed into the lid, and connected to a condensing worm, *d*, by means of a joint, which can be made or broken at pleasure. In preparing magenta, a quantity of aniline, containing about 25 per cent. of toluidine, and a nearly-saturated solution of arsenic acid, is introduced into this apparatus, and well mixed by working the stirrer; the proportions of the materials are in about the ratio of 1 of aniline to 1·5 of a 75 per cent. solution of arsenic acid. When these are well mixed the fire is lighted. After the product has been heated for some time water begins to distil over, then aniline and water, and lastly nearly pure aniline.

This operation requires some hours for completion, and this is determined by inserting an iron rod, from time to time, and drawing out a portion of the product for examination, as well as by the amount of aniline which distils over. When the heating has been completed, a steam-pipe is introduced into the apparatus, and steam blown through the fused mass; by this means an additional quantity of aniline is separated. The lid is then liberated and lifted, with the stirrer, from the apparatus, and the product left to cool before it is removed. A more elaborate and larger apparatus is sometimes used, which possesses considerable advantages over the smaller one. The iron pot is larger and is provided with an outlet at the side, which is closed during the operation, and the shaft of the stirrer is hollow (as in the aniline apparatus described last lecture, Fig. 4), and worked by steam. When the operation of heating is concluded, steam is blown down the shaft, and after the addition of water the product is boiled and run out of the outlet in the side of the pot; by this arrangement it is unnecessary to disconnect the lid of the apparatus, and the product does not require to be removed by mechanical means, a with the apparatus previously described.

The crude product obtained by heating aniline and arsenic acid, is next transferred to vats, boiled with water and filtered. Common salt is then added, which precipitates the crude magenta; this is collected and dissolved in boiling water, again filtered, and the solution, on cooling, deposits the colouring matter in the crystalline condition. This, when re-crystallised, constitutes commercial magenta.

(*To be continued*).

## LONDON ASSOCIATION OF FOREMEN ENGINEERS.

On Saturday the 6th ult., the ordinary monthly meeting of members took place at the George Hotel, Aldermanbury, City, Mr. J. Newton, Royal Mint, president, in the chair. The sitting was principally devoted to business closely connected with the institution, and it was very numerously attended. After the confirmation of minutes of the preceding meeting, the nomination and election of new members was proceeded with. These latter operations occupied a considerable portion of the evening, for never since the formation of the Association were the candidates for admission, on any one occasion, so numerous. Each election is preceded by a statement of the individual qualifications of the would-be associate, and then an open vote is taken; a majority of at least two-thirds of those present being required to secure admission. The following gentlemen were unanimously elected as honorary members:—Messrs. George Waller, of the firm of Burton, Sons, and Waller, Holland-street, Blackfriars-road; Edward R. Allfrey, of the firm of Messrs. Humphrys and Tennant, Deptford; Richard Moreland, sen., of the firm of Moreland and Son, Old-street; James Shand, of the firm of Shand and Mason, Upper Ground-street; Frank Ives Scudamore, Secretary General Post Office; George Robertson, of Leadenhall-street; and Thomas Hall, of Bouverie-street. Mr. William Thorburn, general foreman to Messrs. David Napier and Sons, York-road, Lambeth, was elected an ordinary member; and Messrs. T. Hughes, J. F. Wolff, J. E. Reed, H. Noble, R. Wood, and J. Bates, were nominated in the same category.

It now seems evident that employers and employed are alike interested in the progress of the Association, and equally determined to promote its interests. Under such circumstances, the institution cannot fail to increase in influence and importance, and that to an extent as yet scarcely calculable. In view of this prosperous state of affairs, it was unanimously resolved that the local habitation of the society should be transferred to more commodious quarters, namely, the City Terminus Hotel, and where its future sittings will therefore be held. It was also announced that Professor Tyndall would, in all probability, deliver an inaugural and scientific lecture before the associated foremen, at their new rooms, on the evening of Saturday next, April the 3rd.

## ROYAL GEOGRAPHICAL SOCIETY.

At the evening meeting of this society on the 8th ult., Sir Andrew S. Waugh in the chair, a paper was read by Dr. W. A. Bell, jun., "On the Basin of the Colorado and great Basin of North America." The communication proved to be of great interest, and, together with the further description given by Dr. Bell, in answer to questions of members, was listened to with marked attention by a large audience. The author while travelling in North America joined the Survey Expedition despatched by the Union Pacific Railway Company to determine the best route for a southern line of railway through New Mexico and Arizona to California. In the course of the survey the author traversed the western part of America between the 33rd and 31st parallels of latitude, recrossed the great interior plateaux further north, and travelled through the Mexican province of Sonora from north to south. His paper was confined to a description of the country between the Rocky Mountains and the Sierra Nevada of California, south of the Columbia river, which, he stated, was divisible into two great areas, the basins of the Colorado comprising about 200,000 square miles and the great basin about 280,000 square miles. These two basins are separated on the south and east by the Wahsatch range of mountains, which form a belt 60 miles in width, and the Colorado basin is limited on the east by the great watershed of the continent, the Rocky Mountains. The upper and middle part of the Colorado region forms a succession of table-lands rising higher and higher one after the other, and doomed to sterility by the extraordinary circumstance of all the rivers flowing through narrow chasms worn by the action of their waters to a depth of thousands of feet below the general surface of the country. The Colorado flows for about 300 miles through a winding chasm of this nature, and all its tributaries flow through branch chasms. Their formation was explained by the erosive action of running water throughout long ages, aided by the scantiness of the rainfall, which prevented the sides of the chasm (or canons as they are called) from being washed down into gradual slopes. The "Great Basin" was described also as a tract of desert country, traversed north and south by numerous short parallel chains of hills. The rainfall in this region was not sufficient to enable the rivers to force through the barriers of their lake basins and find their way to the sea; the result was numerous salt lakes, of which that occupied by the Mormons was the largest. The "Great Basin" formed a great triangle, sloping from the north gradually to its apex on the Pacific coast, in the southern part of California. The author believed that this region would eventually become fertile by the application of irrigation. Owing to the Rocky Mountains terminating at about the 35th parallel and the Mexican chain

(Sierra Madre) commencing further to the south-west, the country of Sonora, being thus exposed to the winds from the Gulf of Mexico, enjoyed a much more humid climate and was well watered and fertile. The hostile Apache Indians had hitherto prevented Arizona from becoming settled by the white race. A most interesting section of the American aboriginal race were the Pueblo Indians, who were of Aztec derivation, and had migrated northwards, building everywhere large towns of stone and *adobe* on hill tops, before the Spanish conquest of Mexico. Dr. Bell described several of the Indian towns and cities which he saw on his journey.

## ENDURANCE OF THE WOOLWICH GUN.

Some very interesting gunnery experiments were lately carried on, to try four different systems of construction:—1. The old Armstrong pattern; 2, Frazer's modified Armstrong, with steel tube three inches thick, and over it one mass of wrought iron, coiled and welded; 3, Fraser's also, but with a steel tube only two inches thick, the wrought iron exterior being in two parts, the outer shrunk over the inner; 4, Palliser's heavy gun with coiled inner tube and cast-iron cast over the exterior. About 600 rounds were fired with each, and they remained sound, except the Palliser, which was cracked in the tube near the muzzle. There the experiments ceased for the time, but they are now in progress again. The guns are all of 9-inch calibre. The Fraser gun, with thin steel tube, has since been fired another 500 rounds with battering charges, and remains perfectly serviceable. The test which it has hitherto endured is as follows:—

First 400 rounds with 33lb. charges, the vent being at the rear of the charge; then 200 rounds with battering charges of 43lb. At this stage the gun was wanted for experiments at Shoeburyness, and was re-vented for the purpose. There it was fired 14 times with 43lb. charges. Before continuing the test it was decided to do so with the vent in the service position. The gun was accordingly turned round and vented in its previous lower side. It has just completed its third series—500 rounds, this time all with 43lb. battering charges. From the commencement the projectiles have always weighed 250lb., the service weight.

The gun has, therefore, fired up to this time 400 rounds with 30lb. charges and 250 projectiles, and 714 rounds with full battering charges of 43lb. of English large-grain cannon powder. This makes about 19 tons of powder and 121½ tons of shot. The steel tube is worn at the seat of the shot, but remains in excellent condition for firing. No gun, either English or foreign, of equal size has endured so severe a test. Indeed, it may be said that no piece of heavy ordnance is ever likely to be called upon to stand such an extraordinary trial on real service.

## TRIAL TRIP OF A SCREW STEAMER WITH MORTON'S EJECTOR-CONDENSER.

A trial trip of a new twin screw steamer, fitted with Morton's ejector-condenser, took place on Tuesday, the 15th ult., for the purpose of testing the applicability of this new invention to marine purposes. The system of condensation devised and patented by Mr. Alexander Morton, manager, Messrs. Neilson Brothers' Albert Engine Works, Glasgow, which was described and illustrated in The Artizan for January last, has during the past few months excited a large amount of attention among engineers both at home and abroad, on the Continent, and in America; and as it has just been applied for the first time to marine engines on board the Clyde-built steamer *Flora*, the performances of the steamer on her trial trip have been very anxiously looked forward to, especially by shipbuilders and marine engineers. The *Flora* is a twin-screw steamer, of 208 tons B.M., just built by Messrs. T. B. Seath & Co., Rutherglen, and fitted with two high pressure engines. She was built on speculation, and designed to have great carrying power and little draught of water. On learning of the existence of such a commodity in the market, Mr. Ingle, chief engineer to the Pope, immediately communicated with the builders, but expressed his desire to have condensing instead of high pressure engines. Mr. Morton's new condenser being then talked of by almost every engineer in Glasgow, and the builders having the utmost faith in it, they bethought them to give it a trial in the vessel in question. Mr. Ingle came from Rome to see The vessel, and the condenser in operation at Albert Engine Works, and was so much pleased with the work of the condenser, and so thoroughly satisfied of the principle on which it was constructed, that he at once decided to have the vessel, and to have her fitted with Mr. Morton's ejector-condenser.

On Thursday last there was a preliminary trial trip of the *Flora*, when both the engines were used as condensing engines. The result of that trial was in every sense of the term satisfactory, so far as the new condenser is concerned—the vacuum produced averaging 12lbs. per square inch, the mean steam pressure being 50lbs. per square inch, and the revolutions averaging from 80 to 90 per minute. With both engines condensing, however, it was found that the steam pressure fell from want of draught in the funnel; but the remedy was at hand, as such a state of things had been looked for, and preparations had been made in anticipation of the same. By the simple turning of a stop-cock, one of the engines became transformed into a high pressure engine, as originally designed, and immediately the steam pressure increased.

On Tuesday, after some slight alteration had been made in the furnaces, the *Flora* was again subjected to a trial, both as regards speed and efficiency. A number of gentlemen interested in the results of the trial were on board, in addition to Mr. Ingle, the builders of the steamer, and Mr. Morton. The *Flora*, well laden with cargo, attained an average speed of 10·3 miles per hour between Govan and Dumbarton, a speed greatly in excess of that which was guaranteed by the builders, and with which Mr. Ingle expressed himself highly satisfied. The revolutions of the engines numbered 112 per minute. The *Flora* is one of the several steamers which Messrs. Seath & Co., have built on the same model. By the adaptation of Morton's ejector-condenser to this steamer there is an extraordinary reduction in the weight of the necessary machinery, as compared with that of the ordinary system of condensation, and there is, besides, very great economy of space. The *Flora* is to ply on the Tiber, and hence the necessity for a light draught vessel, and one capable of easy manipulation in a river with numerous windings. It is curious to notice that this valuable improvement in the steam engine has, in respect of marine application, been first adopted by the smallest mercantile marine in Europe—that of the Roman States.

## MILITARY ELECTRICITY.

Mr. Abel, F.R.S., Chemist to the War Department, give on the 12th ult., a very interesting lecture on "Some applications of electricity to naval and military purposes," at the Royal Institution. The lecturer confined his remarks to the use of electricity for land or water mines. Franklin in 1751, and Priestly in 1767, suggested the possibility of applying the electric spark for the ignition of gunpowder charges, but the first practical application was made by the French military engineers about 30 years ago, after Volta had discovered the properties of the pile which bears his name. Not long afterwards English military engineers employed the same apparatus to destroy the Round Cliff at Dover, and remove the wreck of the *Royal George*. Since then many instruments have been devised to act either by heating a piece of thin wire introduced into the circuit, or employing a magnetic arrangement to give a spark which shall pass through a very sensitive explosive composition, and so create the first heat necessary to fire the whole charge. The lecturer rapidly sketched the history of manifold inventions, French, English, American, German, and Austrian, carrying forward the first idea to the point now attained, when a hundred mines can be exploded simultaneously by electrical agency. Mr. Abel himself designed one of the best fuses that has ever been used for the purpose. In the Abel fuse a spark, generated by revolving magnets, is made to pass through a mixture of subphosphide of copper, subsulphide of copper, and potassic chlorate—materials which are of high conducting power, yet extremely sensitive to the action of the spark. This is most, important, for the electrical spark passes with such rapidity as frequently to dash away from it, without igniting, the compositions exposed to its action This fuse and the apparatus which inflames it have long been used for the proof of guns and experimental practice. But the most important military application of the means for exploding charges of gunpowder or gun-cotton is, doubtless, to be found in the employment of torpedoes. The Russians tried torpedoes to be fired by electricity during the Crimean war; but the mines themselves were too small and the electrical arrangements deficient in certainty. A far better arrangement was invented by Baron von Ebnor, of the Austrian Engineers, and employed by him in defending the approaches to Venice in 1859, and again with further improvements in 1866. In neither of these years was there an opportunity for trying the new agent in actual war; but the Americans made much use of mechanical and electrical torpedoes in their great struggle. Many a channel way blocked by them, many a Federal and even a Confederate ship was blown up by torpedoes. A committee appointed to investigate this subject in England has prepared a most elaborate report, which is intended to be kept strictly confidential. Mr. Abel was secretary to the committee, and important revelations were expected on Friday last; but the lecturer was careful to avoid anything of the kind. The English system is, however, so far developed as to render its instant application to coast defence possible in case of threatened attack. The new torpedoes can be laid down rapidly in large numbers, rendered sensitive or not at pleasure, and fired by the blow received when the vessel strikes them. Thus, our own ships can pass to and fro over them when they are left out of circuit; but if the enemy's fleet approaches, the operators on shore can, in a moment, place the whole array of hidden mines in complete preparation, so that when any one of them is struck it will explode, and break the back of the unwary vessel, or blow a large hole in her, beneath the water line. Furthermore, means have been devised for testing each torpedo at any time after it has been laid down, and as often as may be wished. Numerous classes of officers receive instruction in torpedo warfare, and there can be no doubt that submarine mines will be hereafter largely employed, both as auxiliaries to forts and as protections to unfortified coasts or harbours. In the latter case a few light gunboats or floating batteries must be ready to prevent the enemy from fishing up and carrying away the dangerous inventions. Mr. Abel's lecture was illustrated by a series of highly successful experiments.

## THE REPORT OF THE SPECIAL COMMITTEE ON BREECH-LOADERS.

The report on the Special Committee on Breech-loading Rifles has just been laid before Parliament. The proposed arm for the British soldier is the Martini-Henry, firing the Boxer cartridge and Henry bullet. The report informs us as to the course which the competition took, the tests to which the selected arm has been subjected, and which it has satisfied, and the reasons which induced the committee to prefer it to other systems. Taking the breech mechanism question first, it appears that the general course of the experiments to which the rifles were subjected was as follows :—The arms were carefully examined, and 20 or more shots were fired for rapidity, sand was thrown over the breech actions both open and closed, and the rifle fired without any cleaning except what would be done with the hand ; three cartridges purposely damaged to ensure an escape of gas, were fired to test the safety of the arm with imperfect ammunition. If the arm passed through these trials satisfactorily, and if the breech action appeared suitable for military purposes, it was put through a course of long continued firing, being allowed to rust at intervals between the days of firing. The test for rapidity was not applied merely for the purpose of observing how fast the arm would fire, but as a test also for simplicity and convenience of manipulation. The sand test was intended to represent the effects of dust or sand on arms when used in dry countries, especially in India. The long continued firing and rust tests represent the ill usage which arms in war time may have to endure. There were 65 arms in all to be tried for breech mechanism. The tests applied were most searching, and ultimately the guns were reduced to two—the Henry and the Martini. The principal points to be considered were safety, strength, number, and simplicity of parts, facility of manipulation, cost. As to number of parts, the Henry has 49, the Martini 27. In simplicity of construction, the committee believe that the Martini has the superiority. As to facility of manipulation, both systems appear to be all that can be desired, although the absence of a hammer gives the Martini a slight superiority, and in the Henry there is the possibility of placing the cartridge over the extractor. In cost of manufacture the Martini is stated to have the advantage. Finally, the committee prefer the spiral spring to the side lock, which, from experience and from evidence, is liable to become wood bound. Accordingly the committee decided on giving the preference to the Martini breech mechanism. As regards the question of barrel, the report is full of interesting and suggestive matter. In the prize competition to the Henry breech action the prize was awarded in preference to the Martini, while in these trials the prize is awarded to the Martini. What turned the scale was, it appears, the cartridge. In the original trials this was bad in the case of the Martini, but in the new trials the cartridge was good—thus seeming to establish the point that no system of breech actions can be considered independently of its cartridge.

## REVIEWS AND NOTICES OF NEW BOOKS.

*Treatise on Valve Gears.* By Dr. Gustav. Zeuner. Third Edition. Translated by Moritz Muller. London: E. & F. N. Spon, 1869.

This work is a very complete treatise upon the important question of valve gears. Dr. Zeuner has very thoroughly investigated the laws by which the different classes of valve gears are ruled, and set them forth in a sufficiently clear and concise manner, not ascending to a higher class of mathematics than is necessary to demonstrate his mode of treating the subject :—

The author very truly observes that although the trigonometrical method of designing valve gears has been adopted to a considerable extent in some continental countries, yet it has not hitherto found favour in England, and it may be worthy of notice that the eminent inventor of the link motion itself could not have employed any abstract mathematical process in preparing his designs, and since his time the constructive method of detailing valve gears has been largely used as being more simple simple and certain than the trigometrical.

We can however with confidence recommend Dr. Zeuner's work to the notice of students, and more especially to those who enter the profession after experiencing the academical *curriculum.*

*The Year Book of Facts.* By John Timbs. London: Lockwood and Co. 1869.

We have received Mr. Timbs' usual annual *résumé* of the more striking matters which appear in the ephemeral scientific publications. The work useful, inasmuch as it may in some cases save the labour of plodding through long files of papers for information on particular subjects.

Of course Mr. Timbs cannot be held responsible for the opinions contained in the extracts of which the "Year Book" consists, but we think he might find matter more interesting than such as relates to the "American Steam Man," and Ericsson's "Solar Engine," wherewith to fill his pages, both these productions being *un*practicable to the last degree.

Mr. Timbs inserts from the *Times* an article upon the *Hercules,* and we think that, as the "Year Book" is supposed to issue from a scientific source, that some revision should be exercised, or, at all events, that the errors which may be discovered in views published on the launching of a vessel, after that vessel has been tried, should be pointed out. It is stated in the article alluded to, that "the *Hercules* may be summed up briefly as being the best ship the present Chief Constructor has yet added to our navy." Be this as it may, we are inclined to regard the *Hercules* as, in the present state of science, a disgrace to our navy; our reasons have been given in a previous number of The Artizan. In conclusion, we think Mr. Timbs' work would be still more valuable if its matter received more careful consideration.

*Engineering Facts and Figures for* 1868. London and Edinburgh: A. Fullarton & Co., 1869.

Messrs. Fullarton have in this work produced a well considered summary of scientific progress in 1868. We observe one or two oversights, for instance "Boiler Explosions" according to the index should be found p. 71, it is commenced on p. 72, and it certainly is a most interesting and instructive article and one that deserves the most careful perusal, the illustrations add much to its value as showing the various modes of rupture which were observed in the cases reported. We observe that in this epitome some space is wasted on Ericson's "Solar Engine," but in other respects we can cordially recommend the work to the notice of engineers and scientific men.

*Laxton's Builder's Price Book for* 1867. London: Morgan & Chase, and Simkin & Marshall. 1869.

This handbook again appears revised and extended according to the exigencies of the trade. It maintains its position as one of the most convenient price books issued, and is too well established to need any further recommendation.

*British Railways as they are and as they might be.* By John Imray, M.I.C.E. London: E, & F. M. Spon. 1869.

This is an excellent pamphlet on the British Railway System and a proposed method of improving its present unsatisfactory condition. It is well worthy of the attention of engineers and railway financiers.

*On Artificial Drying or Desiccation, with a description of Davison's Patent Thermantérion.* Edinburgh: Edward Ravenscroft. 1868.

Mr. Davison, under whose auspices the *brochure* before us is issued, seems to have devoted considerable attention to the subject of desiccation, and his patent "Thermantérion," or hot-air fan, has proved itself admirably adapted to the purposes for which it has been designed.

The pamphlet commences with a lucid account of the general principles which characterize the operations of drying and desiccation, in which is set forth the drying effect of currents of air, statistics being given relative to the evaporation of water under different circumstances. Finally, there is adduced from the introduction the axiom "that drying can only be properly conducted by forcing, either artificially or naturally, currents of air through, between, and amongst the substances to be dried, this air, or forced air, being more or less elevated in temperature."

The second chapter contains a description of the the thermantérion as to its arrangement and construction; and the third illustrates its application to the industrial arts, and several letters are appended testifying to the perfectly successful results obtained from its use. By the employment of Mr. Davison's process, it appears that a very considerable saving is effected both in time and cost, and as the mode of treatment has stood the test of upwards of twelve years experience, it may be regarded as thoroughly established.

*Van Nostrands Eclectic Engineering Magazine* (Monthly). D. Van Nostrand New York.

We have received the first two numbers of this new engineering publication. It does not profess to contain original matter, but is merely intended as a selection from home and foreign engineering serials

From the two numbers before us we form a very favorable opinion of the work, as it appears to be arranged with considerable skill and judgment; it will certainly form a convenient series of books of refereuce.

*Annales du Génie Civil.* Paris: Eugene Lacroix, Quai Malaquais.

The March issue of this periodical has come to hand. This journal, which has now reached its eighth year, still maintains the tone and interest of the articles contained in it. We notice in this number the second part of an investigation into the principles of surface condensers. On page 158 we observe a statement, which certainly does appear as there set forth parodoxical, which is, that a slight incrustation improves the conductivity of metal. This is according to the experience of Péclet, "le métal parfaitement décapé transmet le calorique moins bien que lorsq'il est légèrement incrusté."

This appears to be admitted by the continental engineers, and undoubtedly it is true if the natural surface were *polished* for it is well known that small points add much in the regular evolution of steam from water under heat, and a slight incrustation would supply such points, but as we never use in boilers, or surface condensers such refined work, we think the majority of English Engineers will dismiss the axiom of Péclet as purely theoretical.

Further on the superiority of the method of condensation by injection over surface condensation is alluded to. Of course that is acknowledged the value of surface condensation being most evident when it is applied to marine purposes, but in the third part the author proceeds to point out that the injection condenser may be conveniently applied to marine engines, but it would require more space than we can devote to this subject to follow out the arguments adduced.

There are several other articles of interest in the number, and we have pleasure in recommending it to the careful notice of our readers.

*Sociètè, des ancens élèves des ecoles imperiales d'arts et metiers. Annuaire.* Paris: E. Lacroix, 1868.

This work forms a reliable record of the Paris Exposition of 1867—it has evidently been compiled with great care, and cannot fail to possess a considerable interest amongst the Engineers of all countries and to form a valuable addition to the library of every Engineer.

*Railway Junction Diagrams.* By John Airey. London.

We have received the "Supplementary Diagrams," recently published in connexion with this valuable work. This is the second supplement issued, the former one appearing in 1868, and it makes the work complete up to date. In calling attention to this last supplement, we wish to confirm the high opinion of the utility of the work expressed on former occasions.

*Scientific Studies.* Two Lectures. 1. "On the Life of the Marquis of Worcester, Inventor of the Steam-engine." 2. "On Chimeras of Science." By Henry Dircks, C.E., LL.D., &c. London: E. & F. N. Spon.

This work, consisting of 88 pages, is illustrated with a neatly-engraved frontispiece, representing Mr. J. Loft's admirable bust of the Inventor of the Steam-engine; and plates of diagrams applying to the second lecture. The reader of Mr. Dirck's exhaustive memoir of the Marquis of Worcester, of which we gave a full notice in 1865, will nevertheless be pleased with this summary biography, which will be found to offer a striking contrast to any of the popular sketches hitherto published. Facts and dates previously unknown, until the author's larger work appeared in 1865, are here succinctly stated; and we find rational dates given for the birth of the Marquis, for the death of his first wife, and of his imprisonment in and release from the Tower; also important facts in reference to his memorable "Century of Inventions." The Addendum—pp. 34-37—is a curious summary, authenticating the existence of the Marquis' so-called "Water-commanding Engine," in which a separate steam-boiler was used, and separate vessels containing the water to be raised. In a note (p. 36), Mr. Dirck's draws attention to the fact of the formation of a public company having been projected for working the invention, as secured in 1663, by an Act of Parliament, for 99 years. The lecture was delivered at the Greenwich Literary Institution.

The second lecture was delivered last year at the Crystal Palace, on chimeras of science: astrology, alchemy, squaring the circle, perpetuum mobile, &c. In the preface the author has given a useful list of works on these several topics. He observes that although his subject is rather discursive "yet it is sufficiently condensed to illustrate fully the truthfulness of the axoim that a little knowledge is a dangerous thing; from its tendency to inspire its possessors with vanity rather than with the humility which always accompanies profound knowledge." It may be the desire of many that Mr. Dircks should have gone more fully into the interesting matters of this lecture, but, as he states in his preface. "It forms a necespart of popular lectures that they should possess breadth with brevity, and interest without too much profundity." In these lectures Mr. Dircks has brought together a large mass of instructive matter, the result of long experience and extensive reading; and few opportunities are omitted for giving a practical bearing to each subject and to point out enlarged sources of information on each topic.

*London Water Supply.* By John Taylor, C.E. London: E. & F. N. Spon. 1869.

This is a reprint of a series of letters written to the *Courier* newspaper in the latter end of 1866 and the commencement of 1867; chiefly having reference to the constant supply question. The letters are ably written and of general interest, and as reproduced are offered in a convenient form.

*Appleby's Illustrated Handbook of Machinery and Ironwork.* London: E. & F. N. Spon. 1869.

We have received this trade catalogue, and examined its contents. It is carefully got up and very exhaustive, being also conveniently classified; there is also much useful information in the work in addition to that which pertains in common to all catalogues. We can recommend Messrs. Appleby's book to the attention of the profession.

*On the Distribution of Rain over the British Isles during the year* 1868. By G. J. Symons, F.M.S. London: Edward Stanford; Simpkin, Marshall, and Co. 1869.

We have received Mr. Symons' valuable record of rainfall in the British Isles. In addition to the tabular matter there are some instructive articles. The first consists of general observations on the different kinds of rain gauges. Mr. W. Menzies calls attention to the importance of registering the maximum rainfall that may come in a minimum time. For hydraulic engineers, or rather that branch of the profession whose attention is occupied with matters relating to water supply, this work has a special interest, and to such must be of great value.

*Power without Fuel.* By James S. Baldwin. New York: W. H. Winans & Co. 1869.

Under this title the author describes a kind of thermomotive engine which he has designed, intended to be worked by the vapour evolved from liquid carbonic acid. The title, "Power without Fuel," is not altogether appropriate, as will appear hereafter, although the changes of temperature requisite to cause the engine to act are proposed to be caused by natural means. The principle of the engine depends upon the fact that the vapour of liquid carbonic acid is much augmented in pressure by slight variations in temperature; hence, by connecting the opposite ends of the engine cylinder with two vessels containing carbonic acid in liquid, and raising the temperature of one a few degrees above that of the other, the differential pressure available to actuate the piston will be considerable; for instance (according to the experiments of Addams), if one vessel has a temperature of 70° F., and the other a temperature of 80°, the available working pressure will be 83lbs. per square inch, the pressures of the gases in the two vessels being respectively 658lbs. and 741lbs. per square inch. The inventor refers to the two principal difficulties which occur at the outset, and which must be surmounted before his theory can be reduced to practice. 1. "The obstacle to the easy and rapid conduction of heat imposed by the necessary thickness of the containing vessels." The mode in which Mr. Baldwin proposes to obviate this is sufficiently feasible, but it is unnecessary here to enter into the details which are given in his pamphlet. 2. "Carbonic acid as now prepared is an expensive gas; hence the waste and leakage which Du Trembley's experiments with ether have shown to be practically unavoidable in such cases, would neutralize the saving in fuel."

Mr. Baldwin proposes to obtain carbonic acid gas by certain processes from *blast and other furnaces*, &c. Here at once falls to the ground the idea of getting power *without* fuel.

Next, as to the means of obtaining the changes of temperature for expanding and condensing. The author refers to the atmosphere as a source of heat, and as a cooling medium, and compares its temperature with that of water. So far, so good, but in mentioning heat from the exhaust of steam-engines, he again loses sight of his main proposition—power *without* fuel. The subject, however, is interesting, and we can recommend the pamphlet to the notice of our readers.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

A new method for drying green wood in a very short time, consists in boiling it for some hours in water and leaving it then to cool, by which the soluble substances are removed. It is then boiled in an aqueous solution of borax, by which the insoluble albumen of the wood is rendered soluble, and escapes from the pores. The wood is then placed in drying-chambers, heated by steam, and allowed to remain three days.

The experiment of making belting from paper has proved a success in the hands of Crane and Co., at Dalton, Massachusetts, and the article is now used in all their own mills and several other manufacturing establishments. The belting resembles the genuine oak-tanned leather, and serves equally well in a dry or damp atmosphere.

In Blackburn, at the present time, out of a million and a-half of spindles, about half a million are entirely stopped, and the half of the remainder are on short time.

A conference was lately held at Darlington between the ironmasters of the north of England and representatives of the workmen, to discuss the desirability of establishing courts of arbitration in the northern iron trade district, and so prevent the periodical disputes and strikes which have been so disastrous to both masters and men. A joint committee of masters and men was appointed to draw up rules for establishing courts of arbitration and conciliation, and to report to a future meeting.

How the Money Goes.—For a long time the Metropolitan Board of Works has steadily refused to allow the cost of the vestrymens' visit to the Main Drainage Works at Abbey Mills, last summer, to be made public. The principal items of expense, have, however, at length leaked out; they are as follows:—The cost of the cold collation, wine, &c., was £1,416 16s. 11d.; steamboats for conveying the visitors from London to North Woolwich, £270; Great Eastern Railway, for special trains to Abbey Mills, £354 13s. 7d.; total, £2,041 10s. 6d.

Metropolitan Street Tramways.—The Metropolitan Street Tramways Bill was brought before the House of Commons for its second reading and, after a lengthy discussion, the House divided, when a majority of 131 was obtained in favour of the Bill being read. Subsequently, on the motion of Mr. T. Hughes, it was agreed that this and all other street tramways Bills be referred to the same Select Committee, a suggestion of Sir F. Goldsmid, that all parties appearing before the committee should be heard without reference to any question of *locus standi*, having been also adopted.

The New York "Pneumatic Dispatch."—It is stated that the Pneumatic Dispatch Company—chartered some time since by the Legislature of New York, but which has attracted little attention for some time past—are now quietly running their underground way from the starting point, corner of Murray-street and Broadway, New York City, towards the post-office in Nassau-street. The work was commenced in the basement of a store at the corner above mentioned, and is being conducted with comparative secrecy in order to avoid the annoyance which would otherwise be incurred from injunctions which might be granted at the instance of stage line proprietors and property owners along the route.

Lighthouses for the Suez Canal.—Orders have been given to French manufacturers for four lighthouses in connexion with the Suez Canal. We understand that one of these lighthouses, that at Port Said, has been contracted for by the Société Coignet and that it will be constructed of *beton aggloméré* made of sea-sand and lime from Theil. The three other lighthouses are to be constructed by the Forges et Chantier de la Mediterranée upon plans which are stated to embrace some novel features.

Proposed International Exhibition in Sydney, Australia.—A proposal for a Grand International Exhibition, to be held in Sydney in 1870, to celebrate the centenary of the discovery and taking possession of Australia in 1770, by Captain Cook, has been made in a letter, by Mr. Joseph Dyer, to the *Sidney Morning Herald*, of October 27th, 1868. Mr. Dyer proposes that the Exhibition should be held in a new central railway terminus which is said to be much wanted in Sydney, and which might as well be built now as in a year or two hence. He suggest Hyde Park, facing Elizabeth-street, as the site, but wherever placed in Sydney, of course the Exhibition could be held in it by way of inauguration. "For three or four months of 1870," he remarks, "Sydney ought to be the Paris of the Southern Hemisphere. The first object of attraction would be the Grand Intercolonial Exhibition, to celebrate the 100th anniversary of the discovery of the colony. Here would be shown the highest efforts we are capable of in art and manufacture, in competition with the productions of the other colonies. Our engineers would show locomotive engines and railway carriages; our carriage builders, boat builders, tweed makers, boot and shoe makers, paper manufacturers, kerosene oil, glass saddlery, tobacco, arrowroot, maizena, wine, and a vast variety of other arts, in which we can hold our own against foreign competition." As the subject of a statue to Captain Cook, the discoverer of the colony, is now being agitated, the proposed Exhibition would form an excellent opportunity for its inauguration.

The Pennsylvania Ironworks, located at Chester, U.S., have just closed a contract with parties in New York for the building of a number of iron colliers for the coasting trade. These vessels will be propelled by steam, and will have a carrying capacity of about 600 tons. They are only the pioneer vessels of a projected large fleet for transporting coal by a cheap means of communication from the most convenient points of shipment to consumers. Some of the large railway companies are also interested in the enterprise.

### NAVAL ENGINEERING.

Satisfactory reports have been received of the performances of the iron-clad *Hercules* on her voyage to Lisbon. Although dragging her large screw propeller, she several times exceeded a speed of ten knots under canvas, and performed the operation of "staying" with great ease. The whole consumption of coal upon the voyage was less than fifty tons, or one-twelfth of the quantity on board. She is also a very steady ship, rolling and pitching exceedingly little, not only under a press of canvas, but with a beam-sea running and little wind. The huge guns (each weighing eighteen tons) were worked and fought every day with perfect success.

The largest iron-clad in the Austrian navy—the largest ship probably ever launched in the Adriatic—has just been launched at Trieste. She is called the *Lissa*. The ship is built entirely of Austrian materials, and every detail of her machinery and armament will be Austrian. Her length is 272ft., breadth 45ft., displacement 6,000 tons. Her engines are of 1,000-horse power, and her armament will be twelve 300-pounder Krupp guns.

### STEAM SHIPPING.

The Dundee Whaling Fleet Fitted up with Steam Winches.—The whole of the whaling fleet leave Dundee this season equipped with steam winches, which have been severely tested, and are found to work admirably. This additional steam power will considerably facilitate the loading and discharging of these vessels.

### LAUNCHES.

Messrs. Richardson, Duck, and Co., of Stockon-on-Tees, lately launched for Messrs. Hornstedt and Garthorne, of Hull, a handsome iron screw steamer, named the *Evadne*. Her dimensions are:—Length, 228ft. breadth, 30ft.; depth, 16ft. 6in.; tonnage, gross, 1,030 tons. Her engines, of 96-h.p., with all the latest improvements, are by Messrs. Thompson, Boyd, and Co., of Newcastle-upon-Tyne.

Messrs. R. Duncan and Co. lately launched from their yard at Port Glasgow an iron screw steamer of the following dimensions:—Length, 315ft.; breadth, 35ft.; depth, 22ft. 6in.; with a gross register tonnage of 2,000 tons. She was named the *Cambrie*, and when completed will form one of the Anchor Line from Glasgow to New York.

Messrs. W. Hamilton and Co. lately launched from their shipbuilding-yard at Port Glasgow, a paddle steamer, for the Ottoman government, of the following dimensions:—Length, 178ft.; breadth, 21ft.; depth, 10ft.; tonnage, 370 tons. As the vessel moved off her ways she was named the *Osmanby*. This vessel is very strongly constructed, being wholly of wood, and copper-fastened throughout. She has a saloon aft on deck, and large cabins forward and aft for the accommodation of first and second-class passengers.

Messrs Denton, Gray, and Co., of Hartlepool, launched on the 16th ult. from their yard at Middleton, the iron screw steamer No. 23 (*Prussia*):—Length over all 207ft.; breadth (extreme), 29ft.; depth of hold, 15ft.; 680 tons; built to Lloyd's rule, class A B. She is brigantine rigged, and her engines are by Messrs. Blair and Co., Stockton, 90-horse power nominal. Her owners are Messrs. Prynn, Read, and Co., Hull, and she is intended for the Baltic trade.

On the 13th ult. Wm. Denny and Brothers launched on the Clyde an iron screw steamship of 1,700 tons. The machinery, of 300-horse power nominal, will be fitted up by Messrs. Denny and Co., on the direct-action surface condensation principle. The vessel was named the *Glenartney*, is the property of Messrs. Jardine, Mathieson and Co., and intended for their trade between Calcutta and China.

A handsome steam yacht, built by Mr. R. Eurlace for Mr. Robert Sherlock, of Plymouth, was on the 13th ult. launched from the Great Western Docks. The vessel's dimensions are:—Length, 30ft.; breath, 8ft.; depth, 4ft.; and her tonnage 10 tons. Her boiler only occupies a seventh of the internal space, and her speed, it is stated, will not be less than 10 knots an hour in a strong breeze.

A fine new iron screw steamer, of 600 tons, built and engined by W. Simons and Co., was launched on the 13th ult. from the Loudon Works, Renfrew. The dimensions of this vessel are:—Length, 170ft.; breadth, 25ft.; and depth, 21ft. She is constructed with a spar deck fore and aft, so that cattle, goods, passengers, &c., will be completely protected. This steamer is classed A B at Lloyd's, and her engines are designed for a very moderate consumption of fuel.

Messrs. Randolph, Elder, and Co., launched from their shipbuilding yard, at Fairfield, on the 1st ult., the *Patagonia* steamship of tons, 3,000 B.M., and 600 horse-power (nominal). The *Patagonia* has been built to the order of the Pacific Steam Navigation Company, is sister ship to the *Magellan*, lately launched from the same yard, and is intended for the Company's direct mail line between Liverpool and Valparaiso. The ceremony of naming the *Patagonia* was gracefully performed by Miss Randolph. Her engines, which are being supplied by the same firm, are constructed upon their patent compound principle.

Launch of H.M.S. "Active."—The *Active* was successfully launched from the Thames Iron Works on the 13th ult. This vessel is a sister ship to the *Volage* which was launched from the same yard a fortnight previously. She is from the designs of Mr. E. J. Reed, C.B., the Chief Constructor of the Navy, and is specially designed to keep the sea for a long period. The *Active* is 270ft. in length between perpendiculars, 247ft. length of keel for tonnage, 42ft. breadth extreme, 41ft. moulded breadth, and 15ft. 2in. depth of hold. Her burthen in tons, O.M., is 2,321 59-94, and she will have engines of 600 nominal horse-power. With this great power to her tonnage, her minimum full-power speed is expected to be 15 knots. Her armament will be six 6½-ton rifled guns, and two 64-pounders. Messrs. Humphrys, Tennant, and Co., are to supply the engines.

### TELEGRAPHIC ENGINEERING.

The recent accident to the *Calcutta* has induced the promoters of the new Persian Gulf cable to postpone the proposed expedition until after the cessation of the monsoon. The *Tweed* will leave probably about the end of May, and will be followed by the *Calcutta*, which is being repaired at Plymouth. The *Caroline* is being fitted out to recover that part of the cable which was paid out from the *Calcutta*.

The imperial Ottoman Telegraph Administration is about to proceed forthwith with the construction of a new direct line to be used exclusively for the Indo-European telegraphic communication, with a view to its improvement. The line will run between Nissa and the Austro-Turkish frontier near Gradiska.

### RAILWAYS.

It is reported in St. Louis that an arrangement has been entered into by which the Illinois Central gains full control of the Mobile and Ohio road, thus furnishing it an additional line of track of 472 miles. In addition to this, some eastern gentlemen have secured the re-opening of the Illinois Southern Railroad from Vincennes, Ind., to Cairo, Ill., thus securing the entire control of the river traffic north from Memphis.

Increased accommodation has been given at the Ventnor station of the Isle of Wight Railway. The directors propose to apply for Parliamentary powers to make a tramway at Ryde to connect their station with the pier.

A Wooden Railway.—A description of the Wooden Railway recently constructed for the Clifton Iron Company between Clifton and the Adirondac mines in New York is given as follows by Mr. C. G. Myers, late President of the Company:—"The rails are of hard maple scantling, 4 in by 6in. set on round ties, on which are framed slots 6in. by 4in. The rails, set on edge and keyed in the slots by two wooden wedges driven against each other, project 2in. above the ties. The rails admit of bending sufficiently to make the curves. The ties are laid on the earth and ballasted in the usual manner to within 2in. of the bottom of the rail. It takes 21,120ft., board measure, of scantling for a mile, and 1,760 ties at 3ft. apart. Our road is a very rough one. We have a great deal of trestle work, some of it over 30ft. high, which is vastly more expensive than a level route. The engines used weigh from 10 to 14 tons. The rails will probably last about 5 or 6 years. An engine will move about 30 tons of freight at about 6 or 8 miles an hour, with heavy grades and sharp curves. The Company expects to move over the road next year from 50,000 to 100,000 tons of freight. Trains have passed over the road, light, at the rate of 20 miles an hour, but this would not do for freight."

The lines uniting the upper portion of the Metropolitan District railway at Kensington and West Brompton with the West London Extension Railway are likely shortly to be opened. A communication will thus be established with the North-Western, the Great Western, and the South-Western lines.

The northern section of the Great Western Railway is now worked entirely upon the narrow gauge. Trains leaving Paddington for Birmingham, Shrewsbury, Manchester, and Birkenhead now run from London to their destinations on the narrow gauge instead of partly upon the broad and narrow. The metropolitan traffic of the Great Western is also partly narrow gauge, and also some of the trains into Windsor. The broad gauge trains are confined to the western district of the railway.

The Shah of Persia has recently granted to English capitalists the monopoly of railroad building in that country for twenty years.

Engineers are now testing the bed of Detroit river, with a view to a railroad tunnel, connecting the Great Western railroad of Canada with the Michigan Central Michigan Southern and Detroit and Milwaukee roads. Tough clay is the result on the Michigan side of the river.

A serious accident occurred on the 4th ult. on the Housatonic Railroad, near Lennox, Massachusetts, when the morning train going north was thrown from the track by a broken rail. One of the passenger cars was precipitated down an embankment, and twelve persons seriously injured.

## DOCKS, HARBOURS, BRIDGES.

A new bridge across the Alleghany river at Brady's Bend was completed on February the 2nd.

The Land's End.—The Trinity Board has resolved to supersede the Longships Lighthouse off the Land's End by a new structure on an adjoining rock. The contract for the granite work has been taken by a French firm, and all the granite for the work will be imported from France. The picking out of the foundation will commence at once.

## MINES, METALLURGY, &c.

Blast Furnaces for Whitehaven.—The establishment of blast furnaces near the town has been long considered a desideratum to the welfare of Whitehaven, and we now hear that there is a good prospect of the universal wish of the inhabitants being realized. Mr. Isaac Armstrong, many years manager of the Cleator Moor Iron Works, is now engaged arranging for the erection of blast furnace works in the immediate neighbourhood of the town. The site selected is the open space in front of the Bransty Quarries. The benefit to the town, harbour, and railways by the establishment of these works, in such a position, will no doubt be very considerable; and the immense quantity of coals that will be required for coking and other purposes, will insure the Whitehaven collieries being more regularly employed than they have been for some time past.

Utilisation of Blast Furnace Slag.—The following method is now adopted in several iron works in Belgium:—The slag is allowed to run direct from the furnace into pits about eight or nine feet in diameter at the top, with sides sloping inwards towards the centre, where they are about three feet deep. The mass is left for eight of nine days to cool, when a hard, compact, crystalline stone is obtained which is quarried and used for building purposes, but chiefly for paving stones. They appear to wear exceedingly well, being quite equal to the grits and sandstones already so much used.

A New Alloy.—A new alloy, forming, we are told, a beautiful white metal, very hard, and capable of taking a brilliant polish, is obtained by melting together about 70 parts of copper, 20 of nickel, 5½ of zinc, and 4½ of cadmium. It is, therefore, a kind of German silver, in which part of the zinc is replaced by cadmium. This alloy has been recently made in Paris for the manufacture of spoons and which resemble articles of silver.

## APPLIED CHEMISTRY.

Chrome Green.—Oxides of chrome are prepared either in the dry or wet way; obtained thus, they vary from greenish grey to a more or less deep greenish yellow. They generally have neither brilliancy nor freshness. It is possible, however, to produce green oxides of chrome which are not devoid of beauty. One of the most intelligent chemists of the commercial world, M. Castbelaz has, conjointly with M. Leune, prepared a chrome green, which is justly styled imperial green. This colouring matter of a superior brilliancy is obtained exclusively by the wet way. The process consists in slowly precipitating chrome salts by treating them with hydrated metallic oxides, insoluble, or but slightly soluble, in water, or by hydrated metallic carbonates, or hydrated metallic sulphides, or again, by salts of weak acids, which easily leave their bases; the action is only produced progressively, and the oxide of chromium is precipitated in the hydrated form; the colour of the compound is magnificent, of a deep emerald green. For this preparation, it is convenient to adopt economical reagents, such as gelatinous alumina, oxide of zinc, carbonate of zinc, sulphide of zinc, &c., whose price is reasonable. The same result may be obtained by treating a chrome salt with the non-alkaline metals, which have a sufficient affinity to unite with the acid of the chrome salt and precipitate the oxide. Iron and zinc will be more particularly used, as they are cheaper. It is necessary to select from among the metals, with their oxides and salts, those which, with the acid of the chrome salt, give soluble salts, as they should be removed by washing. If recourse is had to reagents forming, with the acid of the chrome salt, insoluble salts, it is only in order to modify the colour and composition of the chrome precipitates and of the green colour thus formed. As to the magnificent imperial green colour obtained by M. Casthelaz, it possesses properties which will enable manufacturers ultimately to renounce the justly condemned and dangerous copper and arsenic greens. The use of the imperial green removes all danger from insalubrity; it is an impalpable substance, of perfect tenuity. It is believed that this property will cause the new green to be adopted for printing on stuffs, and for other purposes. The oxides of chrome known up to the present time, and generally obtained in the dry way, cannot, by pulverisation, attain to the degree of fineness of the imperial green. It is expected that this substance will have great success in oil painting, coloured papers colours and artificial flowers, printing, lithography, perfumery, and soap manufacture, as well as in the making of glass and in the ceramic arts.

Professor H. E. Roscoe, F.R.S., lately exhibited and explained to the members of the Manchester Literary and Philosophical Society the method of producing ozone artificially, and showed how it had been proved by Dr. Andrews and M. Soret that ozone was an allotropic condition of oxygen, and that three volumes of oxygen formed two volumes of ozone.

Artificial ebony, now used to a considerable extent, is prepared by taking sixty parts of seaweed charcoal, obtained by treating the seaweed for two hours in dilute sulphuric acid; then drying and grinding it, and adding to it ten parts of liquid glue, five parts gutta-percha, and two and a-half parts of India-rubber, the last two dissolved in naphtha; then adding ten parts of coal tar, five parts pulverised sulphur, two parts pulverised alum, and five parts of powdered resin, and heating the mixture to about 300 deg. Fah. We thus obtain, after the mass has become cold, a material which in colour, hardness, and capability of taking a polish, is equal in every respect to ebony and much cheaper.

Carbolic Paper.—Pagliari, an Italian chemist, has invented a kind of paper wherein carbolic acid is so thoroughly incorporated that the paper, when used to pack animal substances therein, preserves the same in a fresh state without salt or any curing whatever.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 78 | 0 | 0 | 79 | 0 | 0 |
| Tough cake and tile do. | 76 | 0 | 0 | ,, | ,, | ,, |
| Sheathing and sheets do. | 79 | 0 | 0 | 80 | 0 | 0 |
| Bolts do. | 81 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 82 | 0 | 0 | 83 | 0 | 0 |
| Old (exchange) do. | 65 | 10 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 81 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7 | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6¾ | ,, | ,, | ,, |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 21 | 5 | 0 | 21 | 10 | 0 |
| Do. to arrive | 21 | 1 | 0 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 27 | 0 | 0 | ,, | ,, | ,, |
| TIN. | | | | | | |
| English blocks, per ton | 127 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 128 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 133 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 132 | 10 | 0 | ,, | ,, | ,, |
| Straits do. | 129 | 0 | 0 | 130 | 0 | 0 |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 8 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 14 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 7 | 0 | 1 | 8 | 0 |
| IX. do. 2nd quality do. | 1 | 13 | 0 | 1 | 14 | 0 |
| IC. Coke do. | 1 | 4 | 6 | 1 | 5 | 0 |
| IX. do. do | 1 | 10 | 6 | 1 | 11 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 10 | 0 | 6 | 15 | 0 |
| Do. to arrive do. | 6 | 10 | 0 | 6 | 12 | 0 |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 12 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 14 | 0 | 3 | 2 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 7 | 6 | 19 | 10 | 0 |
| Ditto. L.B. do. | 19 | 12 | 6 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 17 | 6 | 19 | 0 | 0 |

* At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated February 17th, 1869.

485 W. E. Newton—Adhesive stamps
486 F. H. Collins—Permanent way of railways
487 A. Ransome—Wood-cutting machinery
488 W. R. Lake—Obtaining benzole, &c., from coal gas
489 H. D. Bowyer and J. L. Norton—Wheat flour

### Dated February 18th, 1869.

490 H. Aland—Blowing fans
491 F. J. Knewstub—Fittings in despatch cases
492 J. Darlington—Mineral and rock drilling apparatus
493 A. Bartholomew—Sliding windows
494 A. Munro and W. B. Adamson—Cutting stone, slate, &c.
495 A. Garrison—Pendant string holder
496 J. D. Nichol and J. Eckersley—Pressing printed paper
497 C. Brook, L Barker, and M. Thompson—Looms
498 R. Pyne—Steps for the doors of railway carriages
499 J. A. Wade and J. Cherry—Pressing bricks, tiles, &c.
500 T. H. Martin—Tightening piston rings in the cylinders of steam engines
501 D G. FitzGerald—Electric telegraphs
502 J. Newton—Spinning flax
503 W. Daines—Anchors
504 F. W. Mallett—Needles
505 M. Vary—Ornamenting surfaces
506 F. Delbriel—Removing and facilitating the utilisation of refuse matter
507 T. Forster and P. Brusey Cow—India rubber suction pipes

### Dated February 19th, 1869.

508 W. M. Cochrane—Vessels for containing water, &c.
509 T. Tunstill and J. Dodgeon—Looms
510 E. Dorsett—Heating metals, &c.
511 A. Heury—Breech loading firearms
512 L. G. Moore—Sails for windmills
513 J. Loader—Steam generators
514 S. Myers—Churns, &c.
515 T. Smith—Treatment of flannel, &c.
516 J. Davey—Motive power engines
517 A. M. Clark—Increasing the tractive power of road engines, &c.
618 E. Hewett—Cowls
519 H. T. and T. Jennings—Steam engines
520 J. Barton—Water heater
521 W. R. Lake—Making ice, &c.
522 M. MacLennan—Permanent way

### Dated February 20th, 1869.

523 G. G. Hairs—Burning and vaporising combustible liquids, &c.
524 G. Green—Buddles for separating ores
525 J. D. Gauldie and T. A. Marshall—Steam engines, &c.
526 J. T. Wibberley—Winding cotton, &c.
527 J. Mabson—Drawing corks
528 A. Jacob—Ventilation of sewers
529 J. Eberhard—Propelling ships
530 H. W. Whitehead—Combing wool, &c.
531 M. Gray—Electrical conductors
532 J. H. Morl—Hair-cutting machines
533 T. H. Simmonds and E. B. Moreland—Glazing linen-faced paper
534 B. F. West—Double-jointed butt hinge
525 F. G. Fleury—Measuring water, &c.
536 J. Daglish—Ventilation of mines
537 R. Foster—Boilers
538 J. E. Lucas—Floating velocipede

### Dated February 22nd, 1869.

539 J. and W. Weems—Malting, &c.
540 W. Abbotson, W. W. Ladelle, and A. Southby—Manufacture of paper
541 S. Osborn—Mowing machines
542 J. O. C. Phillips—Artificial teeth
543 J. W. Reid—Paper pulp
544 W. R. Lake—Heating apparatus
545 G. A. Fall—Propelling vessels
546 T. S. Blair—Iron and steel
547 J. Leach, T. Leach, and J. Goodyear—Winding slivers of wool, &c.
548 B. J. B. Mills—Artificial stone
549 J. E. Liller—Printing
550 J. H. Johnson—Velocipedes
551 W. E Newton—Screw wrenches
552 J. B Rushbrook—Improved hurdle
553 R. Meldrum—Stopping engines, &c.
554 J. Blyde—Scissors
555 H. F. Freutel—Hats and caps
556 R. P. Williams—Railway crossings

### Dated February 23rd, 1869.

557 J. T. Gaze and J. Hymas—Improvements in grate bars
558 A. Jobson—Arrangement and construction of coke ovens, &c.
559 J. Breedon—Taps
560 J. Johnson and W. Gill—Rotary engines and pumps
561 B. W Farey—Gas valves
562 W. F. C. Moutrie—Pianofortes
563 J. Neilson and J. Marshall—Applying trade marks upon metallic capsules
564 A. V. Newton—Fire boxes
565 S. Holroyd—Recovery of substances used in the purification of gas
566 H. Bessemer—Production of cast steel from pig iron

### Dated February 24th, 1869.

567 W. E. Gedge—Hand vice
566 J. J. Myers—Novel method of enabling passengers to warn railway servants, &c.
569 J. Whitehead—Furnaces
570 W. A. Ives—Circular tenons
571 W. Williams—Laying pipes for gas, &c.
572 J. Cooke and G. Hibbert—Steam jets applicable to steam engines, &c.
573 B. Hunt—Regulating friction
574 J. I. Vaughan—Treating metallic salts, &c.
575 R. Morton—Gas
576 G. Rees—Producing designs upon the surface of glass
577 J T. Griffin—Harvesting machines

### Dated February 25th, 1869.

578 W. H. Tooth—Bricks, &c.
579 E. A. V. Leroi—Work produced by cards of carding engines
580 W. Anyon—Velocipedes
581 H. Loeweuberg—Hats, &c.
582 B. P. Walker—Shaping and finishing metallic articles, &c.
583 W. Turner and J. W. G bson—Improvements in friction rollers
584 J. Moody—Mooring vessels
585 W. Parkinson—Wood-cutting machinery
586 W. E. Newton—Furnaces
587 E. D. Barker—Actuating railway breaks
588 L. Engel—Parasols, &c.
589 F Brady—Switch apparatus
590 W. R. Harris—Weavers harness

### Dated February 26th 1869.

591 W. T. Eley—Firearms
592 H. J. Ledger—Apparatus for enabling passengers to signal the guard of a train, &c.
593 H. Harburg—Musical boxes
594 T. Moore—Raising weights
595 W. R. Lake—Constructing ships
596 J. Cheetham—Winding yarns
597 J. A. F. Suter and T. C. Hinde—Improvements in furnaces
598 G. J. Hinde—Coating iron
599 J. T. H. Richardson—Cutting flint glass
600 J. Townsend—Extracting oils
601 E. Falck—Distributing liquids in a state of spray
602 J. Reap and W. H. Michelmore—Improvements in spring hinges
603 C. Markham—Steam boilers
604 W. A. Herring—Pumps
605 C. Williams—Motive power

### Dated February 27th, 1869.

606 J. Adams—Signalling between passengers, &c., of railway trains
607 W. Thomas and W. Davis—Winding machinery
608 J. R. Croskey—Looms
609 R. Pyne—Railway buffer carriage
610 J. H. Johnson—Measuring raw silk
611 C. Maw—Cartridges, &c.
612 T. S. Blair—Effecting the mixture of molten cast iron with solid oxides
613 E. Chapman—Carding engines
614 T. Atkinson—Lighting fires
615 R. S. Norris—Getting coal
616 G. J. Snelus—Reducing iron ores
617 L. G. Lysons—Apparatus for signalling from the marker's butt, &c.

### Dated March 1st, 1869.

618 P. S. Regnauld—Fixing the lid of tin canisters, &c.
619 J. Ladley—Twisting wool
620 R. J. Goodbody and R. E. Donovan—Treating tobacco
621 J Rust—Improved composition
622 W. E. Gedge—Firearms, &c.
623 W. Simpson and A. Gardner—Construction of engines
624 A. H. Brandon—Metallic cartridges
625 W. R. Lake—Mowing machine
626 D. Davies—Getting coal
627 J. Cliff—Substitute for firebricks
628 J. Hadley—Decorticating apparatus
629 A. H Honegger—Copying press
630 B. C. Crawford—Steam boilers
631 C. E. Brooman—Spring mattresses
632 J. G. Willaus—Iron and steel

### Dated March 2nd, 1869.

633 W. Olley—Saw benches
634 J. Farrington—Apparatus for travelling with ease, &c.
635 F. N. Gisborne and H. Allman—Construction of tubes
636 J. Hall—Horse shoes
637 J. Townsend and P. Forbes—Purifying oils and fats
638 J. Woods, J. Hampson, L. Fish and G. Fish—Weaving
639 J. Howe—Navigable vessels

### Dated March 3rd, 1869.

640 W. Clark—Shearing horses
641 F. A. Gatty—Obtaining the colouring matter of madder
642 J. Cooke and G. Hibbert—Motive power engine
643 J. Sloper—Perforating, &c.
644 H. W. Goldring—Cleaning cotton seed
645 R. Low and S. Hargreaves—Warping
646 F. Andoe—Fire escape
647 J Robertson and J. Shanks—Forges
648 E. Lyous—Lamps
649 W. Howes and W. Burley—Carriage lamps
650 H. A. Bonneville—Doubling stuffs, &c.
651 W. E. Newton—Waterclosets
652 R. Wright—Railway carriages, &c.

### Dated March 4th, 1869.

653 D. Sword—Supplying water to cattle trucks or waggons
654 A. A. L. P. Cochrane—Marine structures
655 W. H. Tooth, sen., and W. H. Tooth, jun.—Furnaces
656 E. T. Hughes—Casting chain
657 M. G. Cole—Watches
658 T. Howcroft and A. McGregor—Reaping, mowing, &c.
659 S. Marsden—Bolts and rivets
660 T. Greenwood—Screw gill roving frames
661 J. B. Spence—Purification of gas
662 T. Forster and R. Taylor—Printing rollers
663 W. MacRae—Velocipedes
664 J. H. Johnson—Dyeing, &c.
665 W. Betts—Ornamenting and producing trade marks on capsules
666 J. Gough—Cylinders for containing and distributing colour, &c.

### Dated March 5th, 1869.

667 C. Tighe—Studs, &c
668 C. D. Abel—Injector
669 F. Windhausen—Freezing machines
670 W. E. Gedge—Apparatus to preserve from oxidation iron ships
671 H. Knight—Clipping horses
672 H A. Bonneville—Fastening the knots of neckties
673 C. E. Brooman—Manufacture of fabrics by the employment of fur
674 W. B. Waterlow—Stamping press

### Datrd March 6th, 1869.

675 J. Holding—Looms
676 J Loader—Rotary engines
677 R. Badger—Shears
678 W. S. Meldrum—Carding engines
679 J. B. Spence—Purification of gas
680 A. Morrall—Threading needles
681 T. Ross—Slides for magic lanterns
682 H. and J. Ellis—Cranes
683 W. G. Simon—Improved hank
684 R. R. Bevis—Screw propellers
685 A. M. Clark—Envelopes

### Dated March 8th, 1869.

A. M. Clark—Envelopes
686 A. Dixon—Lubricators
687 J. A. McElroy—Rotary motive power pumping apparatus
688 J. B. Rowcliffe—Wire cloth for paper making machines
689 W. Burr—Compressed leather
690 W. A. Gilbee—Raising water
691 J., J., E., and W. Pitt—Drilling, turning, or cutting metals
692 C. Mather and W. Rossetter—Warping and weaving machinery
693 C. Fairbairn—Furnaces
694 L. M. Ruiz—Purifying and clarifying all sorts of oils
695 H. Tylor—Spring bottoms for bedsteads
696 P. Buchan and A. Guild—Preparing for spinning jute
697 J. A. Jaques, T. Oakley, and J. A. Fanshawe—Surfacing rings
698 H. W. Cook—Regulating clocks
699 J. P. Budd—Iron and steel
700 R F. Piltz and T. H. Lee—Manufacture of paper hangings
701 R. Turnbull and J. G. Piton—Signalling from one part of a railway train to another, &c
702 T. Baker—Umbrellas
703 W. B. Thompson—Finishing textile fabrics
704 A. Mitchell—Cutting stone
705 W. Saunders and C. Smith—Board frame for dressing bags
706 W. Saunders and C. Smith—Combined chess and cribbage board

### Datrd March 9th, 1869.

707 W. R. Lake—Converting a reciprocating into a rotary motion
708 F. F. Villepigue—Velocipedes
709 W R. Lake—Tilt hammers
710 R. Briggs—Regulating the internal temperature of rooms
711 J. J. Shedlock—Wet gas meters
712 J. J. Shedlock—Dry gas meters
713 H. A Bouneville—Porcelain
714 H. Mason, G. Hartley, and J. Hindle—Looms for weaving
715 I Hudson—Tilts for casks
716 J. Dickie—Uniting parts of grates, ranges, stoves, &c.
717 B. Hunt—Road locomotives
718 W R Lake—Turbine wheels
719 A. M. Clark—Fabric applicable as umbrella coverings
720 H. W. Goldring—Soap
721 G. Goldsmith—Signalling from one part of a railway train to another
722 G. H T. Finzel—Cooling and sifting ground animal charcoal
723 R. M. Caffall and D Miller—Rendering walls impervious to the action of water
J. Henderson—Manufacture of iron
725 J. Edwards—Permanent way of railways, &c.
726 W. Saunders and C. Smith—Dressing case and bag
727 G Spencer and J. Barker—Preserving animal substances
728 T. Obach—Fuel economisers
729 W. Walker—Expansion slide valve gear

### Dated March 10th, 1869.

730 W. R. Lake—Devices for rendering gas burners self lighting
731 B. Britten—Whips
732 W. Weldon—Obtaining certain compounds of manganese from chlorine residues, &c.
733 J. Sax—Improvements in the receiving instruments of A. B. C. telegraphs
734 W. Knowles—Mules
735 R Rule—Weaving ornamental fabrics
736 C., W., and J. Drake—Breaking stone, &c.
737 F. O. Palmer—Conveying goods, &c.
738 G. Spencer—Preserving corn
769 A Moncrieff—Mounting ordnance
740 D. Johnson—Decorticating grain

### [Dated March 11th, 1869.]

741 J. B. Bernier—Preservation of yeast
742 T. H. Hairisson—Back-wash chamber for waterclosets
743 W. Wells—Apparatus for sanitary purposes
744 G. Glover—Imparting colours to hydro-carbonaceous fluids
745 W. H. Clapp—Signal lanterns
746 J. and A. Waddington and F. Bell—Condensing steam
747 W. Betts—Capsules
748 C. H. Cooper—Whip sockets
749 J. Bathgate—Gas meters
750 W. E. Newton—Cases for holding cigars
751 W. E. Newton—Adjusting cords, &c.
752 T. Greenwood—Preparing the short drafts of dressed silk
753 J. H. Johnson—Artificial fuel
754 H. Ormson—Boilers
755 J. M. Napier—Metallic moneys, &c.
756 G. Smith—Finishing woollen cloths
767 F. R. Aikman—Firearms
758 T. Beeley and D. Hanson—Welding and flanging plates
759 W. R. Lake—Spinning

### Dated March 12th, 1869.

760 W. Coxhead—Goloshes
761 E. F. R. Lucas—Manufacture of soluble phosphate of lime
762 H. J. B Kendall—Preservative paint
763 J. Porteous and H Gibson—Manufacture of tobacco, &c.
764 D. S. Price—Paving for roads
765 E. Pritchard—Safety button
766 G. Bray—Connecting and disconnecting apparatus
767 J. Cooke—Ploughs
768 H. J. Senant—Steam cocks
769 C. E. Brooman—Manufacture of salt from salt water
770 L. Labadie—Magnetic regulator
771 J. Duffey—Railway brake
772 A. M. Clark—Pulp for paper

### Dated March 13th, 1869.

773 H. C. Bartlett and A. G. Southby—Paper making
774 W. H. Harfield—Capstans
775 J. B. Palmer—Matches and fusees
776 H. Delattre—Tissue
777 P. B. O'Neill and W. H. McNeight—Suspending blinds and shutters
778 E W. and M. Slade—Cooking apparatus
779 J. Thomas—Firearms
780 C. Vero—Hardening and felting hats
781 J. Thumlinson—Paper and textile fabrics
782 W. T. Carpenter—Gas apparatus
783 W. R. Lake—Firearms
784 J. Tenwick—Ovens

### Dated March 15th, 1869.

785 J. Henderson and T. Brown—Water cocks
786 W. A Martin—Steam in boilers
787 E. Sands—Rotary motion
788 J. C. Shaw—Card Grinder
789 C. D. Abel—Healds
790 H. D. Rawlings—Filling bottles
791 J G. Jennings—Irrigating land
792 G. P Evelyn—Sails, rigging, etc.
793 J. R Cooper—Breech-loading firearms
794 W. R. Lake—Steam vessels
795 W. R. Lake—Drilling Machine

### Dated March 16th, 1869.

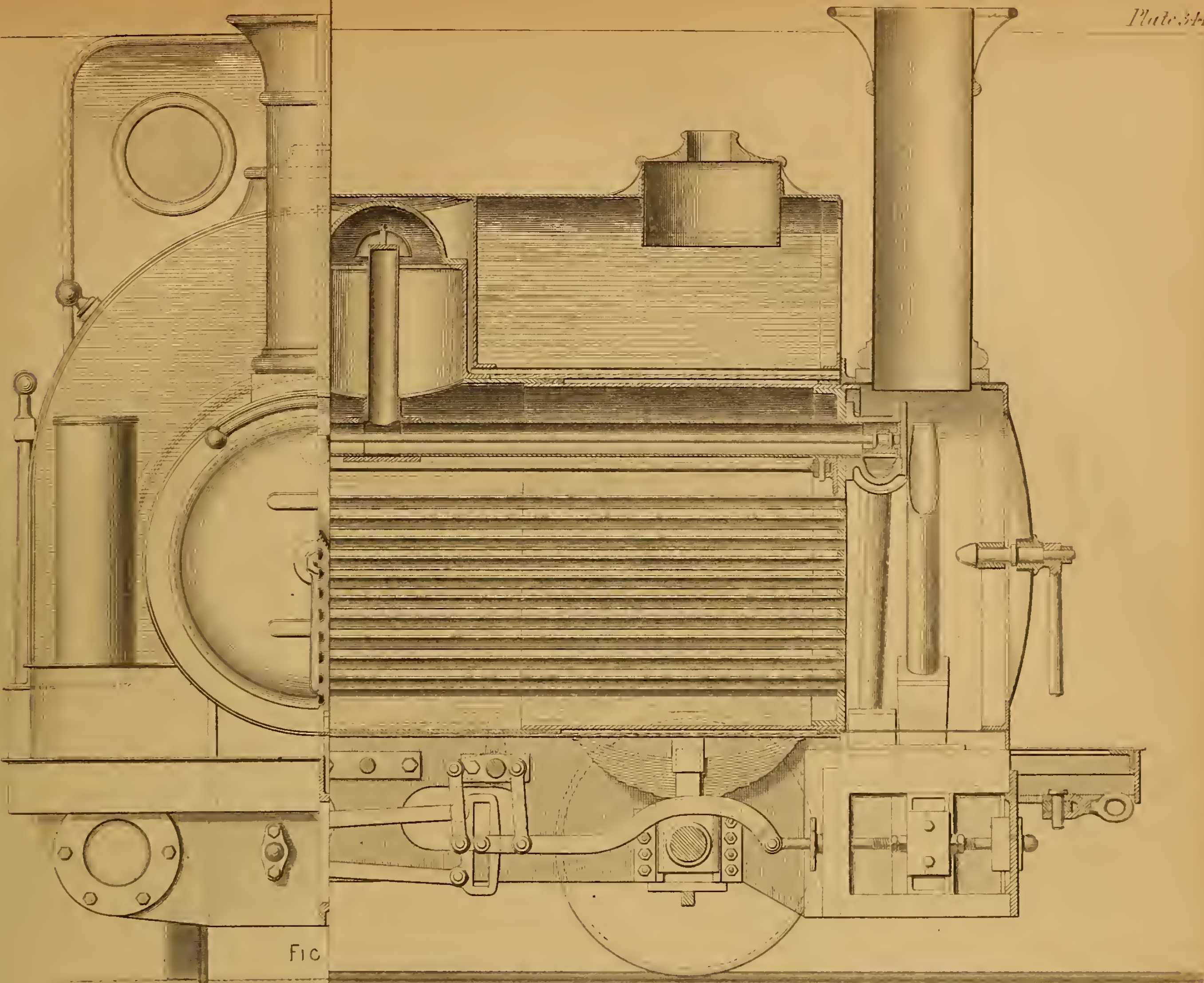
796 J. Taylor, R. Ingham, and J. Sharplis—Carding engines
797 W. A. Lyttle—Overland land wires
798 W. McAdam and S. Schuman—Packing bottles
799 O. Whittaker, and H. and I. Wallwork—Saddles
800 F. Render—Transport of Minerals
801 W. Campion—Sewing machines
802 W. Robertson—Mules and twiners
803 L. Engel—Umbrellas, etc.
804 J. L. Norton—Looms
805 W. and C. S. Catt—Carriage shafts
806 E. Roper—Printing blocks, etc.

### Dated March 17th, 1869.

807 J. James—Powders into pellets
808 E. W. P. Gibbs—Velocipedes
809 B. Latham—Straining sewage
810 T. Rickett—Velocipedes
811 J. J. G. Damitte, J. M. Agnellet, and H. D. Dubois—Pulp
812 H. Claughton—Screw Propellers
813 J. Heywood—Tapes for blinds, etc.
814 M. Rourke—Textile fabrics, etc.
815 J. Carter—Night soil closets
816 Henry Starr—Safety hook for harness
817 F. Gillham—Hats, etc.
818 J. H Bennett—Steam engines
819 C. F. Claus—Carbonate of Potash

### Dated March 18th, 1869.

820 J Ramsbottom—Ventilating railway tunnels
821 T. Martin—Supplying ammunition, etc.
822 G. R. Mather—Cutting wood
823 J C. Ramsden—Looms
824 E. Booth, W. P. Gaulton, and J. Walls—Regulating the admission of air to steam boiler furnaces
825 J. H. Johnson—Firearms, etc.
826 J. T. Darke—Sewage
827 A. de Pindray—Smoke consuming apparatus
828 W. R. Lake—Anchors
829 S. and A. Haycraft—Stationary engines
830 J. Partington, jun.—Smoke consuming apparatus



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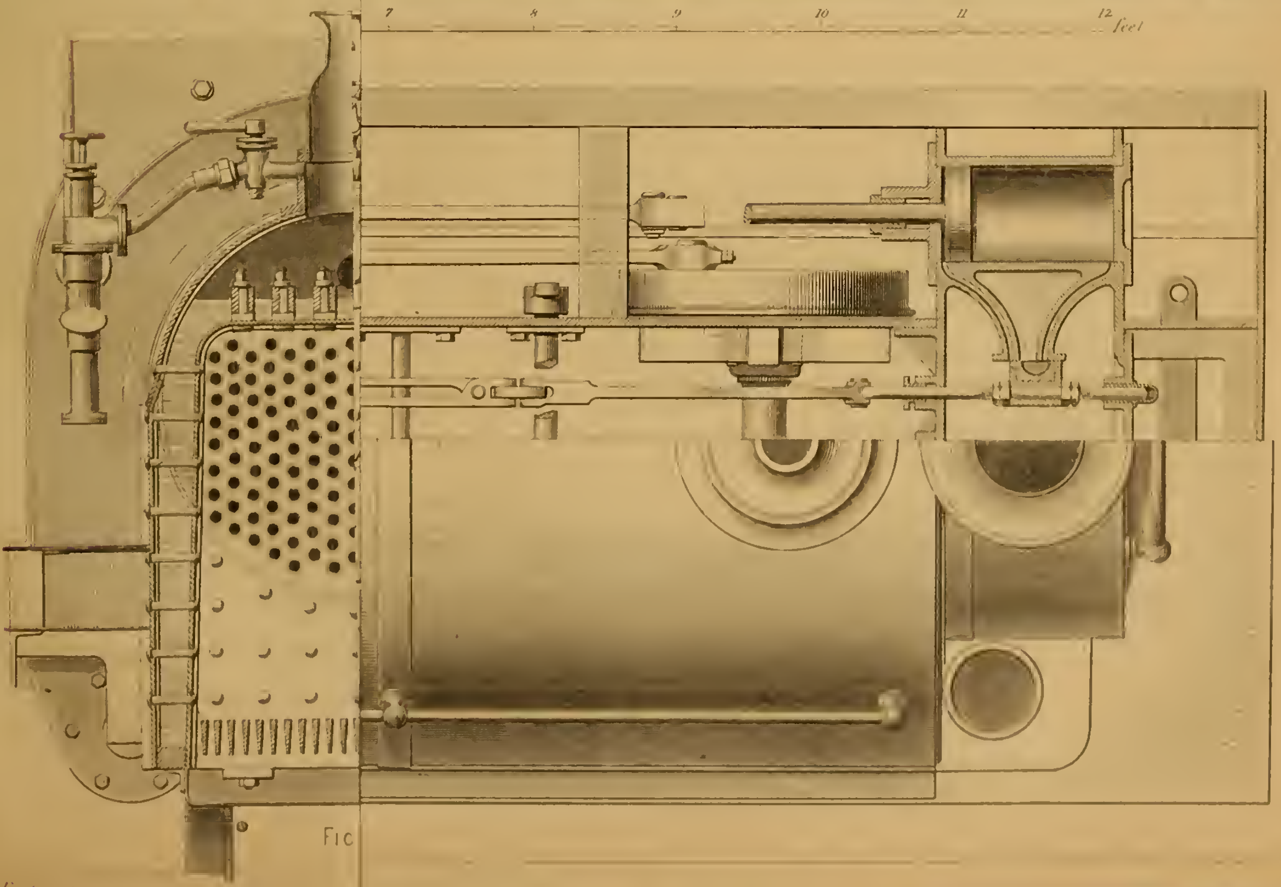


Fic

W. Smith C.E. direx

# NARROW GAUGE LOCOMOTIVE,

BY MESSRS. G. ENGLAND & CO. ENGINEERS,

*LONDON*

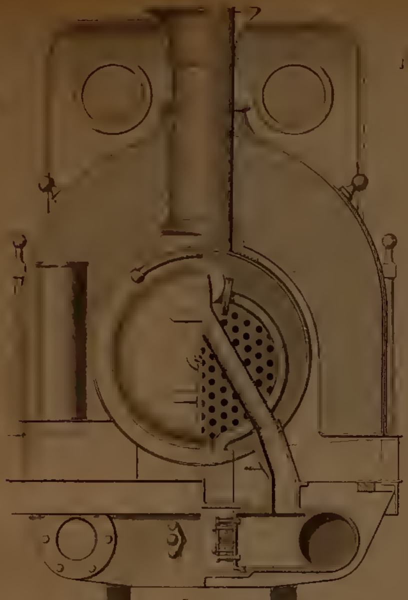


Fig. 3

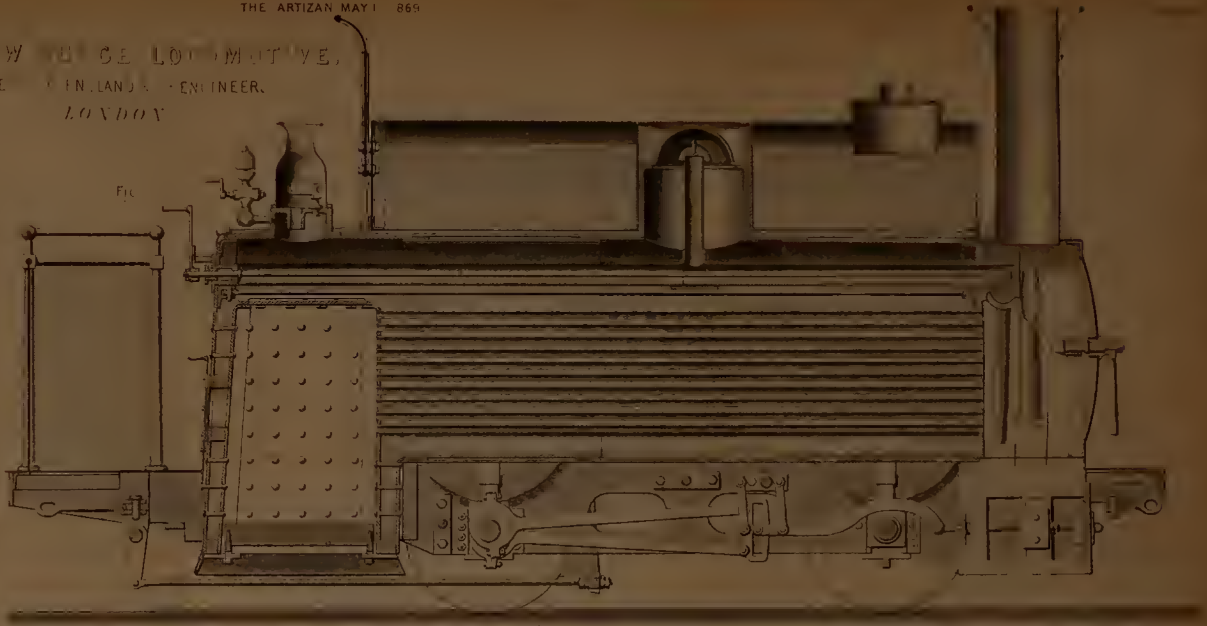


Fig. 1

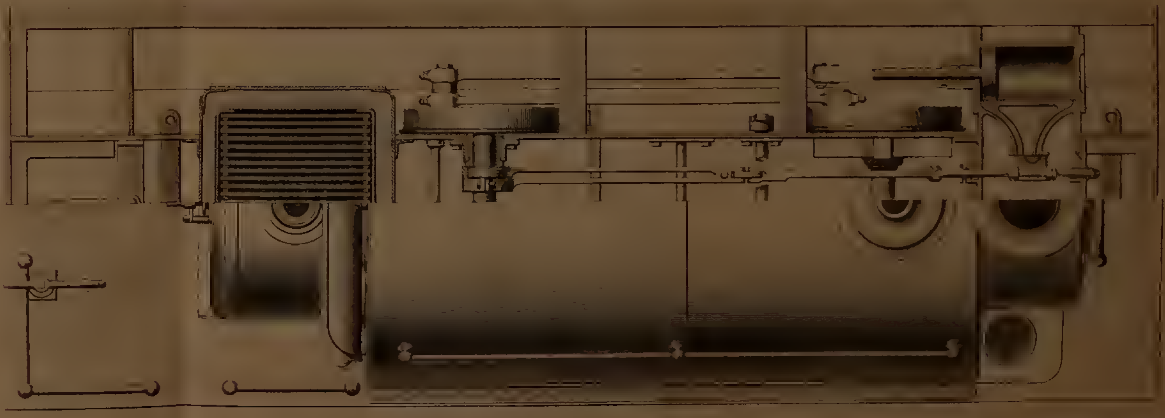


Fig. 2

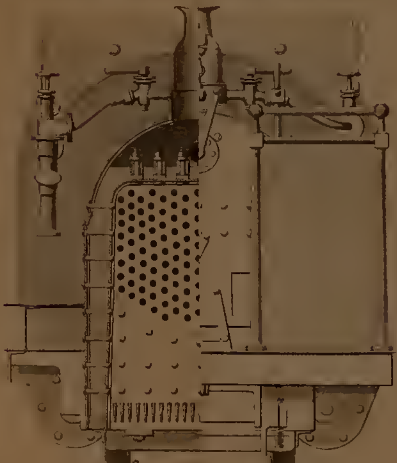


Fig. 4

# THE ARTIZAN.

No. 5.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. MAY, 1869.

## NARROW GAUGE LOCOMOTIVE.

By G. England & Co., London.

(*Illustrated by Plate* 344).

The "battle of the gauges" which was fought so determinedly under the respective leaderships of Stephenson and Brunel, occurred such a long time ago, that comparatively few engineers of the present day remember all the arguments and experiments which were produced on each side in support of the opinions of the opposing parties. That the result of the battle was a decisive victory for the narrow-gaugites is of course well known, but, at what cost it was obtained is not so thoroughly recognised. The opposing railway engineers who, up to that period had been content with engines capable of carrying moderate loads at moderate speeds vied with each other in the construction of huge monsters each one of which was bigger than any of its predecessors; reminding one of the present struggle between guns and armour plates, where neither contending party shews any sign of giving in. If this latter, the cost cannot of course at present be estimated, although it can even now be put down as tremendous, and of the former a much better estimate might be made if the published accounts of the various railway companies were capable of being understood. Some of the consequences however, have for many years been felt by the older railway companies and are now so generally appreciated that a reaction has set in. Thus, it was soon found that those heavy engines driven at an excessive speed were constantly discovering weak places on the so called permanent way, and consequently shortly after the question of gauge was finally settled, the speed of the trains was materially reduced; but even then it was found necessary to strengthen the permanent way at an enormous expense. The system of coupling the wheels and distributing the weight of the engine more equably has no doubt contributed towards the alleviation in the wear and tear of the permanent way to a large extent, but, we think, the weight is still out of proportion to the strength of most of the existing lines of railway. Another evil arising out of the battles of gauges was the enormous length of wheel base to which the engines gradually attained, for, as the engineers had to limit their designs to a certain width, the only way to keep on increasing the power of the engines, was to make them longer and longer until the curves in the line prevented any further elongation.

As has already been mentioned a reaction has lately taken place, and many railway engineers are advocating a large reduction in the weight of the entire rolling stock; for, if in order to save the permanent way the locomotive is to be made lighter the weight to be drawn must be lighter. By this it is not, of course, meant that fewer goods are to be carried as those are conveyed at a slow rate of speed; but in the case of passengers who always insist upon travelling at "railway speed" the weight of the rolling stock, which enormously exceeds the weight carried might be advantageously reduced. It is strange that the various railway companies do not endeavour to remedy this anomaly, for we may be sure that no private firm when once they know they were injuring themselves by using anything unadapted to their purpose, would go on for years without attempting some change. Another alteration that has some advocates is in the gauge of the line, and not being satisfied with the narrow gauge victory propose a still smaller gauge. This of course could only be practicable in England in the case where there is not the slightest chance of effecting a junction with other lines and would therefore be of very limited application; still there have been several of such lines proposed, as for instance a 3ft. 6in. gauge at Manchester, and an overhead line in London to connect Islington with the city, a notice of which has already appeared in the Artizan. An account of the proposed narrow gauge line from Manchester to Didsbury was given a few months ago to the Manchester Institution of Engineers by the president Mr. W. W. Hulse, in which it was stated that the railway would be partly in a cutting and partly tunnelled. The tunnel would only be 10ft. 6in. high; the quickest curve four chains radius and the maximum gradient 1 in 50. The locomotives were not to exceed 15 tons, to run on 40lb. rails, and the carriages were to be 6ft. wide, 6ft. 6in. high, and built omnibus fashion to held 24 passengers. The weight of the carriages would only be 5 tons each and the speed 25 miles per hour. The first cost of this line was estimated by Mr. Hulse at less than two thirds that of a line of the usual 4ft. 8½in. guage, and the working expenses at a similar reduction. In new countries the objection to anything but a 4ft. 8½in. gauge does not apply, and there have been many instances where narrow gauge lines have been laid. Thus in Queensland, Mr. Fitzgibbon has adopted the 3ft. 6in. gauge, and contends, that while it is considerably cheaper it will be sufficient for the traffic of that country for many years. We cannot, however, agree with him upon either of these points, for although it is somewhat cheaper to construct, the difference where the land can be obtained for a trifling sum—if not for nothing—is not very great, while a line of such a narrow gauge must be laid and kept very accurate or the rolling resistance—not to say the danger—would be very great. Again to say that such a gauge will be sufficient for a great many years to come is a rather bold assertion, and one which is not borne out by the experience of the growth of many of our colonies; while the expense and inconvenience that would eventually have to be incurred, when the traffic outgrew the lines, would be enormous.

There is one description of traffic, however, where none of the objections just mentioned are applicable, viz., where the railway is employed for a specific purpose, such as conveying minerals a short distance over or through a difficult piece of ground. It is well known that for such purposes a narrow gauge has been in common use for a great many years, and in fact it is considerably older than any of our public lines in existence. As a very interesting example of such a line may be mentioned the Festiniog Railway, one of the engines of which is illustrated in the accompanying Plate (344). This engine, which is of a number made for the same line, by the well-known firm of Messrs. G. England and Co., Hatcham Ironworks, has been constructed to run on a 2ft. gauge. The line is about fourteen miles long, no portion of which is level, but is entirely made up of gradients, varying from 1 in 50 to 1 in 80, with a great number of curves, some of which are only 1¾ chains radius. The usual load for the engines is 50 tons, which they easily draw at a speed of about twelve miles an hour. The following are a few of the leading dimensions:—Cylinders, 8in. diameter, 12in. stroke; diameter of wheels, 2ft. (four coupled); wheel base, 5ft.; heating surface in fire-box, 22 sq. ft.; tube surface, 350 sq. ft.; total, 372 sq. ft.; area of fire grate, 4 sq. ft.; capacity of tanks, 400 gallons; do. of coal bunkers, 4cwt.; weight, in working order, 10 tons. An inspection of the Plate (344), will enable our readers to form a correct idea of all the other particulars. We may, however, mention one peculiarity, viz., that in order to get the machinery conveniently within so small a width, the eccentrics are forged on the crank shaft, which is made of steel. This plan, of course, does not admit of setting them afterwards, but if carefully done, no adjustment would be required, and it has at least the merit of never shifting afterwards. The workmanship, we need scarcely add, is remarkably good, and fully sustains the reputation Messrs. England and Co. have deservedly gained for the excellent character of their work.

## MODERN IRRIGATION WORKS.

We read in *The Englishman's Overland Mail*, of Calcutta, dated March 9th, 1869, that the area irrigated by the Ganges and Eastern Jumna canals for the late Khurreef (Autumn) crops, amounted to about 446,000 acres, that is, to one-fifth of the total area under cultivation. During the year the increase in the area irrigated is given at 90 per cent. for the Ganges Canal, and 50 per cent. for the Eastern Jumna Canal.

Now, by the calculations of Mr. Login, we find that one square mile of canal irrigated land can produce sufficient to feed 1,318 people, but as the area irrigated during the summer is only of two-thirds of the area irrigated during the Rubbie (or cold season), that would give an area of 669,000 acres, or more than 1,000 square miles under irrigation during the present cold season. The total area irrigated during this year of scarcity, by the two canals of "The Doab," will therefore be equal to—say 1,679 square miles, which would thus be brought under irrigated cultivation, and be capable of producing sufficient food for nearly $2\frac{1}{4}$ millions of human beings. According to Lieut. Scott Moncrieff's calculation, however, as we find on reference to his very interesting book on "Irrigation in Southern Europe," the lands irrigated by the Turia canals in Valencia support a population of no less than 1,774 souls per square mile. Now, this calculation would give the numbers as 2,978,546, or nearly 3 millions, instead of nearly $2\frac{1}{4}$ millions, as modestly put by Mr. Login.

Furthermore, upon inquiry, we find that, for the Ganges Canal alone, the revenue for this year is estimated at £250,000 sterling, and, from evidence in our possession, we believe that it *will* realise this large sum of a *quarter of a million*, and this will represent over 7 per cent. upon the cost of the works.

Surely such facts ought to have their full weight and influence, and we ought not hereafter to hear of such wholesale sacrifices of human life by famine, as have from time to time occurred in many portions of Her Majesty's Indian empire.

## SEA-GOING TURRET SHIPS.

By ADMIRAL PARIS, C.B.

(*Continued from page* 75.)

We will now consider the differences between the conditions of stability of these vessels and those of the usual type. The roll of a ship is entirely dissimilar to the motion of a pendulum, and more like that of a "see-saw" with periodical impulses; the motion being greatest when these impulses take place in equal times with the roll of the vessel. Thus a ship with vertical sides having a great difference in displacement for a certain difference in the level of the waves upon its opposite sides than a vessel with tumbling home sides, receives proportionately greater rolling impulses; and consequently the increased stability of a wall-sided vessel over one with tumbling home sides also increases its propensity for rolling, which is still further enhanced by the inertia of the weight of armour-plated sides. The reason why a monitor does not roll to any extent, is because the variation in the displacement of the two sides ceases as soon as the water flows over the deck and causes the meta-centre to fall suddenly, and consequently the impulse ceases before it has had time to put such a heavy mass in motion. On the other hand, the unusual height of the meta-centre causes the monitor to be *fixed* to the surface of the water, and as that varies, she varies with it, but no more, as if it were a portion of the water or the lump of ice which, it will be remembered, has already been employed as an illustration. The truth of these observations has been proved in practice by the ocean voyages of the American monitors. It may, however, be said that there is an important difference between the form of the vessels illustrated in Plate 343, and that of a monitor, as in the latter case the water can flow freely from one side to the other; while in the former it will be stopped by the "inner vessel," or the part of the ship rising from the deck some distance inside her skin. But it is evident that, though the water is stopped by the "inner vessel," it continues to act upon the sunken part of the deck as it would on a monitor, and as the ordinates of stability act as their cube, the influence of the inner vessel would be very small in proportion to the whole breadth of the ship, and, consequently, it is most propable that it would have but little effect upon its rolling properties. It has been observed that monitors roll rather more to windward than to leeward, which was not changed by the pressure of masts and sails; and, in the present case, as the water is prevented from flowing to the opposite side, it will continue to load that on which it first flowed; it is, therefore, to be expected that it will prevent rather than increase the rolling of the vessel. It may, perhaps, be feared that the upper deck would be constantly wetted by the water breaking against the inner sides and shooting up in the form of spray in a manner similar to that observed when the waves, flowing over a sandy beach, suddenly meet with an upright obstacle; but even if this could not be obviated—as it most probably could easily be—it would only be a source of inconvenience and not of danger.

Upon referring to the Plate (343), it will be seen that in the design No. 1, the turrets are situated in a position similar to those of the *Monarch* designed by Mr. Reed, C.B., but a little further apart, as in the monitors, the length thus gained being taken advantage of for the purpose of putting in three guns, so that the vessel can fire a broadside of seven guns. Whatever advantage design No. 1 may possess in this respect, however, it cannot be so strongly plated as that shown in Fig. 2, which is also preferable as being cheaper, handier, and possibly quite as fast, while the four guns are placed very advantageously. The vessel shown in the design No. 3 cannot carry as heavy armour as either of the others, as will be seen on reference to the table, where all the data are collected. Although much has been said about the advantages of a low fire, Admiral Paris believes that the water will wash into the ports of a turret ship quite as much as into the ports of a broadside ship; besides, for acting against vessels which are not plated on the deck, a downward fire is desirable. Although the advantages in this respect between guns situated at 6 metres—or rather, 5·60 metres—and four metres above the water would be difficult to estimate, their is no question as to their superiority, with respect to their freedom from water, over low ports. The advantages of a high and free all-round fire is too evident to require demonstration, and may be obtained in a ship having a fixed bottom with but a small additional weight, as shown by Admiral Halsted.

As regards vessels with revolving turrets, nothing can be better than the designs of Captain Coles, the plating upon the turret being considerably stronger than that upon the sides of the vessel; because a turret ship has the advantage of always placing herself in such a position that the shot can only strike her sides obliquely, thereby increasing the quantity of metal through which a shot would have to pass. But as the turret has to receive blows in every direction, it is necessary that it should be more strongly protected.

As regards the deck, it has been shown in the case of the floating battery, *Trusty*, that placing iron plates beneath the deck planks is not a sufficient protection; the Admiral therefore proposes to place iron plates upon the planks of a thickness of ·05 metres over the outer deck, and of a thickness of ·04 metres on the deck planking of the "inner vessel," these thicknesses being the utmost that was used upon the American monitors which had to fight against forts. By this means the vessel would be entirely covered with armour plating, which is by no means the case of most European ironclads, where an inclination of 5° or 6° would enable a shot from a modern gun to pierce the deck planking and the thin plate underneath, and to strike the side of the ship, beginning with the wooden backing, as was the case with the *Trusty*. By the adoption of this covering, the men would be much better protected than at present; though, as the iron upon the deck of the "inner vessel would soon become polished by the men's feet, it will be necessary to cover them with moveable planks or gratings, which, of course, can be easily done. That portion of the ship outside the turrets would afford a comfortable space for the ship's company. The sides of the "inner ship" would be made with diagonal—instead of vertical—frames (as shown in Plate 343), as these sides will be the main longitudinal strength of the vessel, and securely fastened to each end of the vessel, while, to make them watertight, thin plates should be fitted between the cross angle-irons and all rivetted together. By placing two transverse bulkheads under each turret and bracing them to these longitudinal girders, a very strong foundation will be formed, and the strain distributed over the whole of the ship. The lower sides of the "inner vessel" are curved inwards towards the fore end, in order to allow of a gallery wide enough to preserve the "inner ship" from a ram, and amidships coal-bunkers take up part of these galleries, otherwise they would be too wide, and hold too much water if the vessel was pierced. All provisions and heavy weights, such as machinery, &c., are placed in the "inner ship," in order to make the outer portion of the ship as light as possible, the only weight carried by that being the armour-plate, which of course, is indispensible. The space between the outer and inner vessel, which is throughout sufficient to protect the inner one from being rammed, is divided into a series of water-tight bulkheads for greater security, and the bottom of the ship is constructed upon the celular system. In order to obtain a free all-round fire, Capt. Coles fits the bulwarks of his vessel with hinges in such a manner that they can be let down and hang over the side; but in this position they are liable to be damaged by the waves. It would, therefore, be better to provide a recess lined with iron plates, and running along the water-way into which the bulwarks, if made of thin iron, could be stowed away; a series of eyebolts and pins could easily be arranged so as to fix them up as strongly as permanent ones.

It will be seen, on reference to the Plate (343), that twin screws have been adopted. This has been done because they are the only convenient means of propulsion for ships of light draught; that they enable the vessel to manœuvre better than any other means—a most necessary qualification in modern warfare where rams are employed—and also that they afford more security from accident than single engines, as, should one pair of engines break down, the others with full boiler power are still available. It may be here observed that Admiral Paris recommended in his "Art Naval à l'Exposition de 1867," page 348, the adoption of a species of Woolf engine for twin screws, in which by a very simple arrangement, the high pressure engine on one side gave its steam to the low pressure cylinder on the other. For the mast there is nothing better than the tripod system of Capt. Coles, which, no doubt, will be eventually adopted by a turret ships. As it appears to Admiral Paris that the present plan of fixing the balanced rudder only at the top and the bottom was dangerously weak, he proposes to have a common stern post, but with the gudgeons fixed to the side, instead of right aft, the pintles of the rudder being also on the side and the stern post, and the rudder post slightly bent, so as to bring the rudder in line with the keel. As the whole of the work is in iron the extra thickness would not be objectionable, while the rudder could be shipped or unshipped as easily as at present. As the iron-clads will be at times required to act as rams, it has been thought desirable to supply means whereby the anchors may lifted inboard, and at the Exposition there was a model upon which an arrangement of large cranes or davits was fitted for the purpose. Admiral Labrousse proposed a cathead, turning on its base, and held with a tackle from the masthead, which, together with a second tackle taking hold of the fluke of the anchor, as shown in the Plate (343), would enable the anchor to be brought inboard very easily.

Of the three designs shown in the Plate (343), the second appears to be in most respects the best, as the design No. 1 would be very costly and scarcely, if at all, more powerful. The draught of water in each of these designs is very small, to enable them to go into harbours and through channels which would be closed to most of the present iron-clads; while the flat bottom by which this lightness of draught is obtained, does not impair the speed, as has been proved in the case of the *Dunderberg*, which has steamed 14·2 knots in the hour. As regards the proportion of the length to the beam, the vessels shown in these designs will probably be considered too short, but in the case of iron-clads, where the weight per foot of side is so much greater than in unarmoured vessels, it is probably better to put up with less efficiency in some respects and endeavour to make up the speed by increasing the power of the engines, while an advantage is obtained in quickness in manœuvring.

(*To be continued.*)

## THE ABRADING AND TRANSPORTING POWER OF WATER.

When the very interesting paper on this subject was read at the Norwich meeting of the British Association, by Mr. Thomas Login, C.E., F.R.S.E., it was at so late a period of the sittings that too little attention was, we fear, given to it at the time; but it struck us as being a subject of the chiefest importance to those who are engaged in the construction and maintenance of those great engineering works required for the irrigation of our Indian Empire, and those who are interested in their usefulness and productiveness; and generally the subject of the paper is one of such scientific interest and importance as to merit the most serious and immediate investigation and consideration.

The cost of conducting a series of useful experiments, on such a scale as would be practically useful, in connexion with the application of Mr. Login's theories, to some of the great irrigation canals of India, would be as a mere bagatelle to the vast economies it would effect and the enormous influences it would exert in and upon the construction and maintenance of such works in the future; and it remains, as we conceive, rather for the Government of India than for the Royal Society or the British Association for the Advancement of Science to undertake such a series of experiments as naturally suggest themselves as most necessary, which, to be of real practical value, *ought* to be made and tested here, and must be conducted upon a sufficiently large scale to ensure reliable results.

Mr. Login's paper is full of suggestions, so valuable that it is exceedingly difficult to set a limit to the number of important engineering and other scientific questions involved therein and likely to be affected thereby; but amongst the many questions that have suggested themselves as involved in or affected by the views developed in Mr. Login's paper, we propose giving, from time to time, a few of them in a series of short articles.

### Its Influence on the Consideration of Geological Questions.

The abrading and transporting power of water is admitted to be one of the chief agents nature employs in transforming the surface of the globe, and a knowledge of the laws of this power would open a wide and interesting field of research to the geologist.

If, as is supposed, this power of running water is directly as the velocity, and inversely as the depth, we can at once determine the *minimum* velocity that could transport the matter which forms any description of rock formed by aqueous deposit at given depths. Should this rock be of considerable thickness and show signs of uniform deposit, the fracture being in extended parallel layers, we may conclude that the deposit took place in *deep* water most probably; but if, on the other hand, the stratification is irregular, intermixed with material of different kinds, of various specific gravities and sizes, the natural conclusion is that the deposit was in comparatively *shallow* water, heavily loaded with the matter, and flowing with great velocity. By these means very important geological facts may be established, which would throw light on many vexed questions of the present day.

If water in motion has already got its load proportional to the depth and velocity, it appears evident that, so long as these conditions remain, there can be no tendency to scour or deposit; thus, a river so loaded, may carry in suspension, and roll along, sand or even shingle over a bed of clay without disturbing the bed. This at once explains why we often find deposits with the lightest and finest particles of matter lowest and the heavier deposited over it.

This is shown on a great scale in the Bay of Bengal; the light matter is carried out to sea and deposited in deep water, but as the head of the Bay is reached and the depth less, sand is found overlaying the fine mud; thus, in a series of ages, the deep portions become silted up with clay, and by the strong tides at the Sand Heads, it has sufficient power to push forward the comparatively heavy sand, which it has all the more power to do, by the decrease of depth—for, as previously shown, the transporting power is inversely as the depth.

### Its Action in the Formation of Deltas.

Suppose we take the average yearly rain-fall in a tract of country drained by a river at 4ft., and the actual evaporation at 1ft., the total discharge of water into the sea will be 3 cubic feet during the year for every square foot of area drained..

Again, if we measure the volume of water which flows down the river between its banks during the same period, and deduct this from the total discharge, only the very small volume, comparatively speaking, which inundates the country, can be of use in raising the surface. For the sake of argument, we will suppose this to be one-third of the discharge, there would be thus only 1ft. which conveys earthy matter *from* the river which holds it in suspension, while from this a deduction is necessary, as the rain falling on the land, which drains *into* the the river when it is not in very high flood, must also transport from the spot whereon the rain fell, a certain quantity of solid matter. Small though this may be, it will still be an appreciable quantity, which we will suppose to be one-third of what is deposited by the river while in flood.

Again, supposing the solid matter held in suspension in a river when in flood, is one cubic inch to one cubic foot = $\frac{1}{1728}$, it would take 144ft. depth of water to deposit 1in. of silt; and as only 1ft. is available in the whole year for this purpose, under the above conditions, after deducting the third washed off the soil by the river, it would take 216 years to raise the land only 1in.

Small as the quantity may appear, it is still further reduced by the greater portion of the solid matter being deposited on the river bank, so that before the inundation water has travelled half a mile from the river, having to filter itself through thick vegetation, the thick muddy water of the river will be nearly deprived of its load. So much is this the case, that if we take a tumbler of this flood water out of the parent stream, and drop a silver piece in this muddy water it cannot be seen; but take a sample of this very same water a short distance inland, and we shall find it comparatively speaking clear water and fit for drinking. Roughly speaking therefrom, we may say that the water has at and near the river bank, parted with four-fifths of its load if not more.

Now taking the area drained by a river at 30 times the area of the area of the flooded Delta and from this we obtain $\frac{216 \times 5}{30} = 36$ years which it must take to raise the land of the Delta of a river one inch, and one fifth of that time at the river bank, that is, if the water held $\frac{1}{1,728}$ of its bulk of solid matter in suspension. In round numbers we may say, that to raise the land of a Delta only one inch, it takes some fifty years, while in the vicinity of the river banks, which are constantly falling in and re-formed, and owing to other local causes, the changes may be very great, though the average be small, as for example the Nile is supposed to raise its bed and banks at Cairo some 5in. in 100 years.

The whole argument deducible from the above is, that so far as we are at present affected, or many generations after us may be, by embanking rivers, and thus preventing the land on either side from "warping-up," the injury can be nothing in comparison with the present benefits derived therefrom; so those supposed injuries may be dismissed from our minds, and our attention should be fixed on those immediate evils we are certain of, and when it is known that often plague, pestilence, famine, and even sudden death, are the consequences of floods, it should be our duty to try to ward them off, and leave it to those who succeed us one or two thousand years hence, when science will have greatly advanced to devise some means of overcoming what for many centuries to come, may without danger be treated as a bugbear.

That deltas are being raised by the deposit from rivers is admitted on every hand, but great diversity of opinion exists as to the rate at which this warping up takes place, and some may be liable, from observing certain local changes, to suppose that relics discovered at great depths below the present surface of the ground were deposited at these depths when the surface of the country was at that level. Thus when remains of plants, animals, or even man and his handiwork, are discovered overlaid by deposits, which in the natural course of events, if these deposits were uniformly spread over the land, such raising of the land must have taken centuries on centuries to accomplish. The discoverer, who does not take into account local changes, is liable to be led away into speculations that are neither of use to science, nor to his weak brother, who looks on only the literal translation of the Bible as being a proof of its inaccuracy, The mistake may be on both sides, for what the observer of nature may suppose must have taken thousands of years to accomplish, may have been the work of only a few years, while the literal translation of God's work, which He has given us for our guidance, may lead others to as great mistakes in chronological calculations.

For example: at the present day deep holes, many miles inland, may be found in the channels of our rivers even exceeding 100ft. below the level of the sea, and all sorts of heavy matter may be deposited in them. Supposing the Bassine River, in Burmah, was to change its course at the town of that name, situated more than 70 miles inland, the deep hole below that town, which is rather more than 100ft. below the level of the sea, would get silted up, and this could, without any stretch of imagination, be accomplished in a few years. Now, if a boring should thereafter be made over this spot, and the anchor of one of Her Majesty's ships of war which may have been lost at the taking of Bassine in 1854 was discovered, would it not be absurd to attach great antiquity to this relic; and, admitting that it took 50 years to raise the Delta one inch, to calculate that it took 50 × 12 × 100 = 60,000 years to form the deposit overlaying this anchor? Should such a relic be hereafter exhibited, and some old smith from Her Majesty's dockyards see it, he may, like Edie Ochiltree, exclaim—

"Relics here, and relics there,
I mind the welding o' it."

What is wished to be shown now, is that there are at present sufficient *local* changes on this earth's crust at work to explain many deposits without its being necessary either to attribute great antiquity or any convulsion of nature in their accomplishment. When the abrading and transporting power of water is better understood, much light will be thrown on this interesting and important subject.

### Its Influence on River Channels.

A knowledge of the abrading and transporting power of running water is a matter of the greatest importance in enabling us to deal with questions affecting the improvement of the navigation of rivers.

If certain velocities, with a given depth, can only transport a given quantity or quality of solid matter, it appears evident that, if the quality be changed, or the quantity increased or diminished, the navigable features of the stream must also be affected.

For example: If the up-lands on which the rain falls be thoroughly drained, the water must flow off quicker, and, consequently, the floods down the river must be increased; thus, by the increased velocity the river obtains the power of transporting a larger quantity and denser description of matter than it otherwise could. This heavier material, on reaching the influence of the tidal water, where the fresh water flowing down only bears a small fractional proportion to the volume which flows up and down every tide, at once loses the great *extra* velocity, and the tidal portion of the river remains much in the same state as to its transporting power as it was before the drainage of the uplands took place. As a natural consequence, this heavier matter is deposited in the bed of the river, the deep channels get silted up, and thus, what was once a good navigable river, becomes year by year worse. The injury is not confined to the spot where this deposit takes place; for, by making the upper channels of a river of less depth, the volume of water which flows up and down at every tide is also reduced, and thus the lower reaches of the river, by having this reduced volume flowing through them, become, in time, also shallower.

Again: In our English rivers it has been the habit to discharge all the refuse of our towns and manufactories into them; the load or work thus given to the flowing water, which, except during freshes, is much reduced in power, is more than it can transport; the refuse is deposited over the bed and banks, and thus, not only do our rivers become unfit for fish to live in, but the general health of the inhabitants upon and in the vicinity of its banks is seriously affected, for the putrid mud banks must send forth pestilential exhalations. By a study, therefore, of the abrading and transporting power of water, the *cause* of this deterioration of our rivers will soon be discovered, and, when once the *cause* is known, the remedy will soon be applied.

The navigability, or the necessary depth of rivers to be fit for the purposes of navigation, does, it is believed, in a great measure depend on the geological formation of the country through which the river flows and by which it is drained. If the country drained consists of crystalline, or sandstone rock, it is evident that sand will be the chief material transported; such matter, owing to its size and shape, can only be set in motion by high velocities, therefore, it is only during floods that rivers can bring the sand down, thus, during the greater portion of the year, the water in such rivers is comparatively free from solid matter. When the river reaches the influence of the tides, be the rise and fall ever so great, the whole effect on the river bed is to scour the sand out at one spot and deposit it at another; for, though the velocity in the tidal estuary may be sufficient to transport this sand, yet, as the fresh water stream bears such a small proportion to the volume of the tidal waters, the effect is simply to carry a certain quantity of sand up the river with the flood tide, and during the ebb to pick up a slightly greater quantity and convey it down stream. As therefore the sand of the bed of a river is simply picked up at one point and deposited at another, the channels become shifting and uncertain, and thus the navigation is impeded. When, however, the river is in flood and has greater power, its water-borne load of sand is also increased, for on such occasions only is the river able to transport the *heavy* sand.

A study, therefore, of the geological formation of the catchment basin of a river, as to whether it be crystalline or mud-producing rocks, will at once explain why one river should not be navigable at its mouth, whilst another, which chiefly transports mud or light particles of matter, remains naturally in a navigable condition, unless overloaded with sewage, &c. The total general advance, therefore, of the matter held in suspension is only the proportional difference between the volume of the fresh and salt water. Thus, supposing the mean velocity in the tidal portion of the river is 5ft. a second, and that the discharge is one million cubic feet per second, whilst the volume of fresh water passing down is only 1,000 cubic feet, the general advance of the fresh water during the ebb tide would be $2 \times \frac{5}{1000} = \frac{1}{100}$ of a foot a second, as the fresh water constantly flows downwards, where it is beyond the influence of tides. Thus, instead of the matter held in suspension advancing during the ebb tide 20½ miles, the whole advance is only about 1-5th of a mile. This at once explains why experimental floats have been found to take so long a time in passing down estuaries, and how also the sewage of our cities which is admitted into our rivers is washed up and down the river, and this mostly at a season when the river is lowest and the sun most powerful.

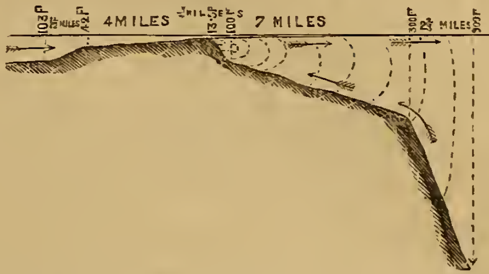
### Its Influence on the Formation of Bars at the Mouths of Rivers.

One of the oldest and strongest of controversial subjects which has been discussed by engineers is regarding the formation of bars at the mouths of rivers; but they appear to be the natural result of two contending forces, and their general direction is that of a horse-shoe, or in a curved line convex towards the sea. By this peculiar form the matter is deposited so as to resist the abrading and transporting power of water by obtaining an extension of length; thus, the volume of water has to be spread over an extended line, and the volume discharged over any given point is reduced to a *minimum*, as in the case of rapids formed by boulders, which generally take a similar form. The matter is thus arranged so as to be able to withstand the scour of flowing water, which it could not do if contracted to a narrow channel.

In some cases, however, where the matter carried down is comparatively light and the outflow of fresh water is very great, in proportion to the tidal water, and this, at the same time, is aided by strong tides in holding the matter in suspension, bars are not formed, but channels are kept open where bars would otherwise exist; these channels are, however, always liable to changes, caused by large floods or by gales of wind. Were floods and tides the sole operating causes, the general direction of these channels would probably be in a direct line to the deepest water; but it has been observed that the course of these channels are bent off by the direction of the prevalent gales.

Again: Where almost only fine mud is brought down by a river, and where there is both a large volume of fresh water and a considerable rise and fall of the tide, without a heavy sea beating on the coast, there is a gradual shelving of the bottom into deep water without either bars or sand banks. Where the sea is almost tideless, as in the Gulf of Mexico, and the river brings down chiefly soft mud, a bar exists, though it only consists of fine mud, but so soft and moveable that it is forced into the Gulf when the Mississippi is in flood; and it again approaches the river in the dry season. This no doubt is caused by the deposits being chiefly inside the bar when the river is low, and when the river is in flood it is picked up and deposited outside the bar. The general advance of the bar seawards is 338ft. yearly, or nearly 1 mile in 16 years.—*See Humphrey and Abbot's report, p.* 443. Through this mud-bar, channels known by the name of passes, are formed by the river at various points; in this case the operating cause is the same; namely, the deposit takes place where the transporting power is no longer able to hold in suspension all its load. Within this bar the river has still the power to hold its load of mud in suspension, the channel being still comparatively contracted, and thus the main channel is deep. but as the fresh water escapes right and left through the passes over the mud-bar, though "the velocity is from 3ft. to 3½ft. per second, sufficient to transport sharp sand or even coarse gravel," it is thus demonstrated that when once water has got a load of matter held in suspension, due to its velocity, it is unable to pick up more, for if it could do so the mud-bar could not exist.

What appears to take place in this case is that the fresh water, being lighter than the salt, the fresh water floats on and over the sea to a depth of from 6ft. to 8ft. just outside the passes. The outflow acts on the salt water below, causing a similar outflow of the upper stratum of the salt water, where the two waters come in contact, till ultimately this fresh water current is overcome and the two waters become mixed. To balance this outflow of the salt water near the surface, a counter current below must flow inwards along the bottom; but, as the fresh water loses its velocity as it gets out to sea, so must it give up its surplus load, and thus there must be a constant sinking of the mud through the several under-currents. By these means the mud which was carried out over the bar by the surface fresh water is brought back by the bottom salt water current coming in from the Gulf to fill up the void caused by the surface salt water which had been forced out by the fresh water. But as the bottom current cannot have sufficient velocity to hold the matter in suspension, it is deposited, and thus the bar is formed (see diagram). What is clearly shown in this case, is that even soft mud is not disturbed by water flowing over it, which has already its load of mud held in suspension, even though the velocity with *pure water* would have been sufficient to sweep away a foundation of coarse gravel.*



With bars at the mouths of our English rivers the case is different, for here we have strong tides, with only a very small volume of fresh water in comparison with that which is salt, so there cannot be this observable outward flowing surface and inward flowing bottom currents, though the flood tide, when first making, may steal in at the sides and even below the out-going ebb, as both waters are nearly of the same specific gravity.

In the case, therefore, of bars to our rivers, if the channels could by any means be contracted out well into deep water, so as to give to the outflows and inflows a sufficient power to keep a deep channel, the probability is that, extending the contraction well out to sea, the currents which flow parallel with the coast would prevent any bar forming. As to the practicability of such a scheme no opinion is offered here. The object is to show that bars as well as any other deposits are the results of the water being unable to transport its load, and thus the depth decreases till the proper balance is established.

### The Effect of Shortening Rivers by "Cut-offs."

The effect of shortening the course of a stream, is, it has been supposed, to deepen the channel by increasing the velocity towards the sea, and, by so doing, to lower the height of floods. As "cut-offs" are often easily made, and as the immediate effect is to lower the flood levels just above the cut-off, private interest will tend to induce a man to try the experiment, whatever may be the effect on the property further down the course of the river.

A study of the abrading and transporting power of water would cause anyone but he who only looks to present self-interest to hesitate before he attempts to shorten the course of a river. If the abrading and transporting power of water increases with the velocity and decreases with the depth; and also, if certain velocities of given depths can only convey a given load, and that there will always be a tendency to adjust the load, or the length or breadth of the stream, according to any change in the conditions, caution should be observed in attempting to deal with nature under such conditions, as inadvertently serious injury may be produced which cannot afterwards be remedied.

If we look at the general character of rivers, one broad feature is that the slopes decrease as the sea is approached; another is that, as a general rule, as the slope decreases so does the relative depth increase, that is, in streams with great fall where they pass through, or rather *over*, alluvial plains, in most cases the breadth is great compared with the depth, or the channel is very tortuous. Nature, therefore, so as to obtain depth, takes a more or less tortuous course; and if we attempt to shorten the course of a river, it may eventually be found that we have made it broader and shallower, if it cannot again increase its length.

The immediate effect of a "cut-off," however, is to lower the surface of the river *above* the cut and to *raise* it below the cut, and this has been clearly shown to be the case on a grand scale on the Mississippi, where certain "cut-offs" have been made.

Mr. Ellet, in his able work on this river, has stated some remarkable facts regarding the effects of "cut-offs," and this lowering above, and raising the surface of the floods below these "cut-offs" is one of them; another is that the velocity is very much increased, yet the widening of the channel is not so soon effected as one would naturally suppose, and Mr. Ellet says that "centuries may roll by before that part of the Mississippi is opened as wide as the average dimensions of the channel."

Now to apply the supposed laws of the abrading and transporting power of water, the above examples prove that, at the top of the "cut-off," owing to the increase of velocity, the immediate effect is to scour out the bed and lower the surface level. In other words, the river, by the increased velocity, has got the power to transport a greater load of solid matter; and this it does so long as this increased velocity is maintained; the moment, however, the river again begins to attain its natural velocity, the water parts with this extra load and the bed is raised; with it the surface level of the river is raised also, and hence the injurious effects on the country along the river below the "cut-off." Regarding the slow process of widening which has been observed, it has been before stated that the channel is deepened, and hence, as the transporting power decreases with the depth, and the river from up above is already (where it flows in its natural state) loaded with its due proportion of solid matter, the water has not such an increased power, as may at first sight be expected, to carry forward more earthy matter. So it is a work of time to widen the channel; but, wherever a new cut is made, the *immediate* effect is to deepen rather than widen the cut where the river *takes* to the new channel.

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* See page 339 of "Ellet on the Mississippi."

This, however, is not always the case; for often a broad shallow cut is made much shorter than the natural channel, and yet the river, instead of flowing down this new cut, silts up its mouth so that the short cut to all intents and purposes becomes useless, and it is owing to the waters of a river highly loaded with earthy matter flowing down at a considerable velocity, having to pass down a much shallower channel than the natural one. The hydraulic mean depth of the new channel being so much less in comparison to the natural one, even though the fall is greater, yet the water has not velocity sufficient to transport the load of silt the river brings down, much less to pick up any more, and so the heavily-charged water of the stream sends down the new channel only a portion of the flood waters, which, parting with its load, forms a bar across the mouth of the new cut and eventually blocks it up.

From the above it will be observed that, in some cases, short "cut-offs" do not act in the manner commonly anticipated, and, when they do act, they are sometimes attended with danger, so that the greatest caution should be observed before deciding upon making them.

It was at one time suggested to cut a new channel for the Thames through the Isle of Dogs, and the probable effect would first of all have been to deepen the channel higher up, so as perhaps to endanger the foundations of London-bridge and other property along the river bank, and after having done all the harm it could in that way, afterwards either to widen the channel, owing to this greater fall, or tend to increase the length of the channel somewhere else, till it got back to its normal state.

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## AMERICAN DREDGING MACHINE.

By D. S. Howard, C.E.

No dredging machine is equally well calculated for all kinds of dredging under various circumstances. Some underwater excavations are required to be continued through dry land, and the deposits made on the banks; at other places the height of the banks requires the excavated material to be put into lighters. As the lighters in such cases cannot be placed alongside at all times, the deposits must be made over the stern. Other work is situated in water sufficient on all sides to float the machine and lighters, which requires another modification of the machinery, in order that it may be economically adapted to the situation.

There are variations of the material also, in which no invariable machinery will work equally well. Wherefore I have generally heretofore constructed dredging machines expressly for particular works, without any view to the execution of any other work. But I have frequently found circumstances to vary the conditions of the same work, so much that two or more machines, very different in construction, are required to complete it with economy.

From these considerations, after long experience in constructing and working dredging machines of various descriptions, under a great variety of circumstances, I have prepared the following plans of a machine, which has been found capable of being adapted to a very large range of circumstances and situations.

Such a construction is more valuable, since the improvements made in the materials, the manufacture and the construction of the machinery render it so much more durable that its usefulness is extended beyond the immediate purposes for which it was originally constructed.

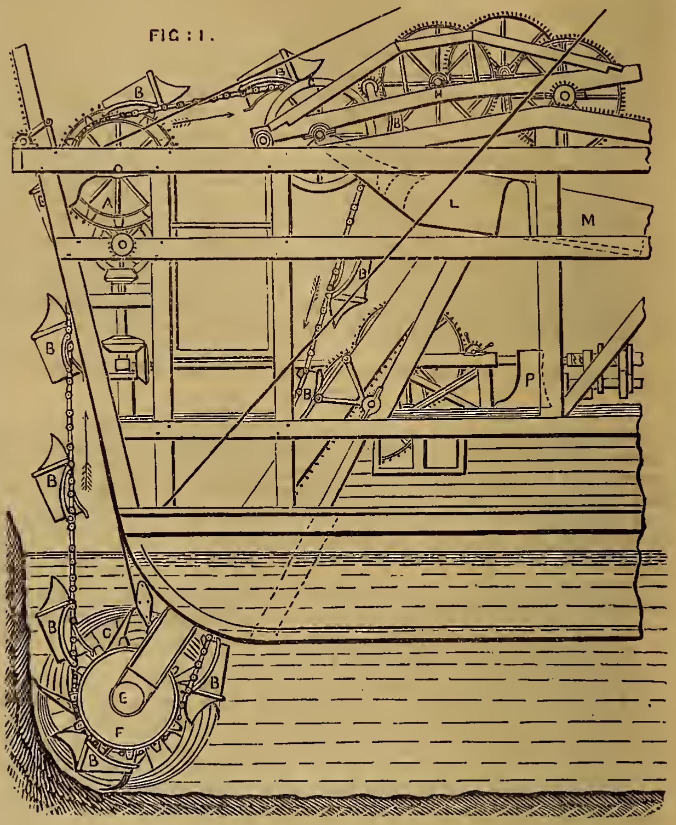
Fig. 1 is a side view of a portion of a dredging machine calculated to deposit in lighters, over the stern or at the sides, as occasion may require. It is also calculated to work with any shaped bucket best adapted to the material to be excavated.

Fig. 2 is an end view of the same, showing the facilities for lateral deposit. The same letters refer to like parts in each.

A is the driving chain-wheel, geared to the engine by the wheels and shafting shown in Figs. 1 and 2.

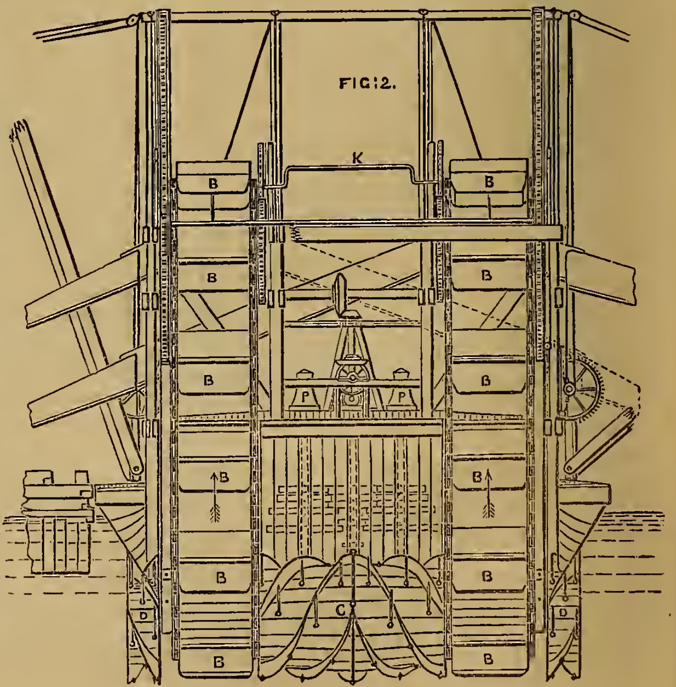
B designates the buckets attached to the chains shown in Figs. 1 and 2.

FIG: 1.



C represents the centre cylinders, with the spiral scrapers and hooks, for loosening and conveying the material to be excavated, from the centre, each way, to the buckets.

FIG: 2.



D, in Fig. 2, represent short cylinders on the ends of the cylinder shaft, E, Fig. 1, with spiral scrapers for conveying the material to be excavated, from the outside to the buckets.

The short cylinder on the port side of the dredge, Fig. 1, is left off, to show the lower chain wheels and the lower attachments to the ways.

F is one of the lower chain wheels, attached to the cylinders and driver by the chains, in the same manner as the chains are driven by the driving chain-wheel, A, by cams fitting into alternate links of the chain.

G is one of the flange-wheels seen in Fig. 1, over which the chain passes before descending to the lower chain-wheels, F.

H is one of the movable frames. which suspends the flange-wheels, G, on rollers running upon ascending ways provided with powerful purchase-wheels, terminating in a pinion working in a descending rack, shown in Fig. 1.

This purchase is worked by a cog-wheel on the flange-wheel shaft (not shown in the drawing), working in a wallower wheel, when thrown into gear, for the purpose of raising the buckets from the bottom when required, by forcing the flange-wheels, G, up the inclined ways. When the machine is not in motion, the wallower wheel may be thrown out of gear, and worked by hand, with a long double crank, K, Fig. 2.

By the motion of the bucket in the direction of the arrows, the excavated material is brought up, and if it is to be deposited over the stern, it is dumped into the movable spout, L, Fig. 1, which is attached to the axis of the flange-wheel, G, by the extension of its sides, and moves freely within the stationary spout, M, allowing the flange-wheel, G, to be drawn up, when necessary, with the movable frame, H, without changing its proper position, for receiving the contents of the buckets as they pass over the flange-wheel, G.

B, Fig. 3, is a perspective view of a bucket used in the arrangement for depositing over the the stern. It is provided with a loose bottom, which drops with the load about two inches, rendering the discharge perfectly certain when at work in the worst kind of material.

When the situation of the work is such as to require the deposit to be made on the bank, or into the lighters alongside, a bucket like B, Fig. 4, is put on the chain, in place of B, Fig. 3, which dumps into the lateral spouts, situated between the driving chain-wheel, A, and the flange-wheel, G, by the tripping of the latch which lets fall the whole under side of the bucket, hinged to the bolt that fastens the bucket to the chain. This insures the discharge of the most difficult material.

The short receiving spouts under the buckets, and the one between them, are hung on pivots in the centre, so that either end may be elevated, and the contents of both sets of buckets discharged on either side, or both sides, as may be desired.

When the work is situated in water deep enough in front of the dredge to float the loaded lighters, the buckets like B, Fig. 5, are brought into requisition, which dumps through the bottom, the latch to which may be tripped anywhere on their perpendicular way up, and discharged into a short vibrating spout, which conveys the material directly into the lighter placed much nearer than it can be in any other arrangement. Thus saving power in proportion to the height of discharge.

A gang of hook, is sometimes put upon the chains between the buckets, when working in hard, coarse material, like cobble stone, shale, or hard-pan. The chain is so constructed that any shaped bucket, or any other device for loosening the material that might be found, in practice, to be preferable, may be put upon it. All the article here represented have been fully tested, and found very useful in their places. No sacrifice of power or of economy in working has been required to enable us to use all these appliances on the same machine; on the contrary, the perpendicular position of the working part of the chains, and their passing around three drums instead of two, are great improvements under all circumstances.

The perpendicular application of power secures a great economy of friction, in the wear of rollers, ways, &c., especially where no lubricating material can be used, nor the wearing parts secured from the destructive action of sand and water, which must always be present in dredging.

The third drum, which constitutes the flange-wheels, G, enables us to raise the buckets from the bottom in the manner above mentioned without changing the perpendicular position of the working part of the chain. It also furnishes the best possible position for the discharge of buckets like B, Fig. 3, at all times when that kind of buckets are in use. Also, that of B, Fig. 4, which dumps between the two upper drums, requiring nearly a horizontal position to discharge.

The bucket B, Fig. 5, is equally well accommodated. This one may be dumped anywhere on the perpendicular part of the chain, by raising or lowering the vibrating spout which trips the latch. This is the most economical of all the different buckets, where circumstance are favourable for its use, as it dumps with perfect freedom all kinds of material, and is discharged at a much less elevation, on account of its better relative position with respect to the lighters.

In working these machines, a pully is anchored at a convenient distance ahead, with a feed line passing from one of the feeding capstans, P, through the pully and back to the other capstan, either one of which, or both, may be worked by the adjustable machinery to any required motion, by a change in a series of clutches above—or a series of wheels below-deck; while the spiral cylinders below water, with the buckets, clear the way to the full width of the dredge, and to the depth required, bringing up the material and depositing it in lighters, or on the banks, or at any any distance in any direction horizontally, not exceeding one in twelve of the altitude overcome, by supporting a spout, lined with sheet iron of the length required, on a movable support, that it may coincide with the feed motion of the dredge.

The distance from the dredge at which the deposit is required, determines the length and inclination of the spouts. Something, however, depends upon the nature of the material excavated. If it contain clay, or vegetable matter sufficient to prevent the water from draining out too soon, it will run on a descent of one inch to the foot, without more water than the buckets bring up with it; but if the material be pure sand or gravel, a pump will be required to assist in the discharge, without more inclination of the spout.

These machines can be constructed with any dimensions to suit the magnitude of the work, provided the proper proportion of the parts be preserved for strength, motion, power, and durability. These considerations are very important for the success of any machinery, more particular such as is supported on a floating foundation.

As yet, I have never been called upon to build a dredging machine that would excavate more than three thousand cubic yards in a day of ten hours, but one may be built, with economy, to raise double that amount, rather than build two for the same work, as only the same number of men are required on the dredge, all the additional help being that required to dispose of the excavated material.

The Central American Transit Company, with William H. Webb as President, and J. E. Body, Vice-President, built one of these machines, on a small scale, in 1867, for the purpose of improving the San Juan river, in Nicaragua, and the harbour at its mouth, which was capable of raising three thousand cubic yards per day, and was worked with great satisfaction, until, by some misunderstanding between the Company and the Government of Nicaragua, the work was suspended.

Another machine, with some of the above improvements, was built in 1857, for the Corpus Christi Ship Channel Company, in Texas, with which the Channel was finished to sixty-four feet in width. without the use of a lighter, except to support the long spout in which was run off the excavated material, on an inclination of one inch to a foot.

## ADMIRAL WARDEN'S REPORT ON THE CHANNEL SQUADRON

The following report from Rear-Admiral Warden upon the qualities of the ships composing the Channel Squadron during the month of June last, is scarcely so interesting as it would have been had the weather proved a little less lamb-like. So far, however, as it describes the behaviour of the various vessels in calm weather it is valuable, and we therefore give it as under:—

"Of all these the *Bellerophon* is the readiest and most easily handled under steam, and she has the most powerful battery under the thickest armour. Under sail she is slow, and stows a small quantity of fuel, but is very economical in expenditure. Her principal defects as a fighting ship I consider to be, that the guns in her battery are placed too close together; the absence of upper deck armaments, and the want of fire in the line of keel, under armour, as well as the inefficiency of the bow-gun, which is on the main-deck. I do not believe that in chase of an enemy's ship she could, by any possibility, fire her bow-gun, the projecting bow helping the sea to roll up to, in, and on her maindeck, flooding it and compelling the closing of the port. On one occasion, 30th of June, when steaming head to wind 5½ knots (force of wind 5), in reply to the signal, "Can you fight bow-gun?" the answer was "Yes, with closing the port occasionally." The absence of upper deck armament is, I presume, to be accounted for by the fact that the ship, as originally designed, was not intended to have any upper deck, and as this was an afterthought, it was prepared to carry guns.

"The next class to be noticed is the *Prince Consort* and *Royal Oak*. They were built to serve a particular purpose, at what was considered a critical period. They were generally viewed as a makeshift, and, being merely wooden line-of-battle ships cut down and armoured, they are not likely to be repeated. Nevertheless, they have good qualities; they are armoured throughout, are powerful ships, handy under steam, from being short, with good speed, and do sufficiently well under sail. Their consumption of fuel is very great. They roll very much, and so deeply that I am of opinion, now that ironclad ships are taking the place of wooden line-of-battle ships, it is worthy of all consideration whether it is not advisable to make them coastguard ships after putting them in a state of thorough repair in every respect; they might then last for years. Under existing circumstances, if they are much at sea, it is not to be expected that they will be worth repair at the expiration of their present commission.

"I now come to the *Defence* and *Pallas*. The former is a very handy ship under sail, especially with her screw raised, is very economical in her expenditure of fuel, but an indifferent performer under steam. A proof of it may be found in the fact that on the 30th of June, when practising evolutions, force of wind 5, squadron steaming 5½ knots, head to wind, with a slight easterly swell, when she lost her station some little distance, she was utterly unable to regain it, although she was making 54 revolutions by signal. On her trial at the measured mile, in March, 1862, 52 revolutions gave her a speed of nine knots, according to the official record. In fact, she never did get into her place, and the evolution was not completed. As the experiments now taking place on board the *Pallas* are to be made the subject of special report, I need not further advert to them in this place, nor do I think it necessary to say more about that ship, as her qualities are sufficiently well known; and I do not suppose there is the least probability of a second ship of the same class being ever built.

"The *Minotaur*, the *Achilles*, and the *Warrior* are three very noble ships. The last named, however, I look upon as the least valuable of the three; her unarmoured ends, exposure of steering wheel, her rolling propensities (as compared with the other two), are defects which are not compensated for by any good qualities superior to theirs. The first and second, notwithstanding their great length, which of necessity carries with it some disadvantages, have many great qualities. They steam at high speed; the *Achilles* is, under sail, everything that could be expected in an armoured ship unable to raise her screw; and no doubt the *Minotaur* would do equally well if she were masted in the same way, which I consider she ought to be the first favourable opportunity. The *Minotaur* is more heavily armed than the *Achilles*, having four 12-ton 9-inch guns on the main deck, and two 6½-ton guns on the upper deck, which fire in a line with the keel, under the protection of armour, being the only ship in the squadron which possesses this advantage, and is armoured throughout, having 5½ inch plates, tapering to 3½in. These are great advantages over a ship in other respects so nearly alike, but in the great and all-important point of the capacity for fighting their guns, they are both alike, rolling as nearly as possible to the same extent, which is a *minimum* as compared with other ships; and of this respect of steadiness of platform upon which to fight their guns, I believe they stand out unrivalled and unsurpassed by any ship which has ever been built. Believing, as I do, that this invaluable property of steadiness is due to the form of the ships, and the preper distribution of the weights on board them, and not to be attributed to their great length, this question has constantly forced itself on my mind—viz., is it not possible to build a broadside-ship, heavily armed, adequately protected, of such a length at to secure sufficient speed, and to be at the same time a handy ship, and of such a shape and form as to roll as little as the *Monotaur* and *Achilles?* Unless this question can be answered positively in the negative, I have a full conviction that it ought to be attempted, so long as broadside-ships continue the most important and formidable part of our navy.

"My own idea of the proper theory of ironclad ships is this, that they should always be built of iron, be armoured throughout, be as heavily armed as possible, and possess bow and stern fire, at least to the same extent as the *Lord Warden* and *Lord Clyde*. Perhaps the time has arrived when the enormous increase in the power of artillery, and the increased weight and thickness of the armour-plates, which have become necessary to resist the projectiles now in use, render the carrying out of this theory of ironclad ships impracticable. If this be so it would seem to follow that if guns are to be used of such a weight that the whole length of the broadside cannot be made use of to carry them, and the space which they occupy is too great to admit of their being protected by a thickness of armour capable of resisting the shot which will be brought against them, it seems to follow, I say, that the turret-ship is a necessity. Guns of any weight can be placed in turrets, armour of almost any thickness can be carried round them, and it will then only be necessary to protect the water-line with a belt, as heavy and as thick as the ship can bear. These conditions carried out, it remains, of course, that the turret-ship should be constructed so that she should be a habitable and comfortable ship for the officers and men, with a sufficiency of sail power to enable her to meet the varied requirements which are usually made on a British man-of-war. The question again naturally arises. Is it impossible to build such a ship? The conditions above-stated, which seem to render a resort to turret-ships inevitable, seem also to point out that, in the broadside-ship, armour-plating will eventually have to be given up everwhere, except at the water-line and at the bow and stern, to protect guns firing in a line with the keel. In ships built completely of iron, with guns as heavy as they are capable of carrying. protection must be reduced to minimum, and shot and shell be allowed to find their way through and through the iron fabric, perhaps with less damage to ship and life than if they had been checked in their progress by armour-plating. The subject of 'ramming' I approach with great diffidence. It is one which exists principally in the region of speculation. I am not one of those who think that in the next naval war ramming will rank before artillery as a mode of attack; but I believe firmly that it will play a very important and formidable part in all future engagements. Possibly some naval actions will be decided by the independent and energetic action of some individual captain seizing the fortunate moment and the right opportunity for running his enemy down at a high speed. It is as clear as anything can be that so long as a ship has good way on her, and a good command of steam to increase her steam at pleasure, that ship cannot be what is called 'rammed'; she cannot even be struck to any purpose so long as she has room and is properly handled. The use of ships as rams, it appears to me, will only be called into play after an action has commenced, when ships, of necessity, are reduced to a low rate of speed, probably their lowest. I therefore apprehend that it would be consistent with prudence and good tactics always, when going into action, to hold in reserve a portion of the squadron or fleet (and that whether the force was large or small, whether the enemy were numerically superior or otherwise) to act as rams; and when the action had commenced, and noise and smoke and fire were doing their work, the reserve to be brought into play to act independently, as circumstances might require. For this purpose ships must be made capable of playing their part, and strengthened on purpose to perform such duty and the form of bow which I believe best calculated to deal the hardest blow, and carry with it the greatest amount of destruction, is the straight upright stem of the *Achilles* or the slightly curved one of the *Minotaur*, rather than the projecting prow of the *Bellerophon* and others of a similar form. The result of the experience gained when the *Amazon* 'rammed' a small steamer in the Channel is not encouraging. I believe also on this subject, as well as on very many others connected with naval warfare, that the first great action at sea between ironclad squadrons or fleets will dissipate and cast to the winds many of our preconceived opinions and theories, disturb many of our prejudices, and throw an entirely new light on the whole subject."

## WEBSTER'S TUBE-PLATE CUTTER FOR STEAM BOILERS.

By the ordinary method of preparing the tube-plates of steam boilers for the reception of the tubes after the sheets are laid out, with lines that intersect at the points corresponding with the intended centres of the tubes, the centres are first marked with a punch; small holes are then drilled through the plate, and the latter is finally bored to the size required with a pin or teat drill. The first small holes are required for the steadying of the teat drill making the larger holes for the tubes.

The object of the invention shown in the accompanying engravings is to dispense with that portion of the labour hitherto required for the drilling of the preliminary small holes, and this end is secured by means of a tool that may be centered in the centre-punch or prick-punch markings, where it is held steadily while the holes for the reception of the tubes are being bored through the plate by the advance of the cutters.

To attain this end the apparatus consists of a new arrangement of a circular cutter and spring centre, by which the circular head forming the cutter is fitted to the tool-stock and is retained by a key working in a slot. When the centre is placed in a centre-punch marking, the drill may be fed down to the plate and passed through it, while the centre remains in the marking and holds the cutter securely, the spring yielding gradually as the boring and the feeding progress.

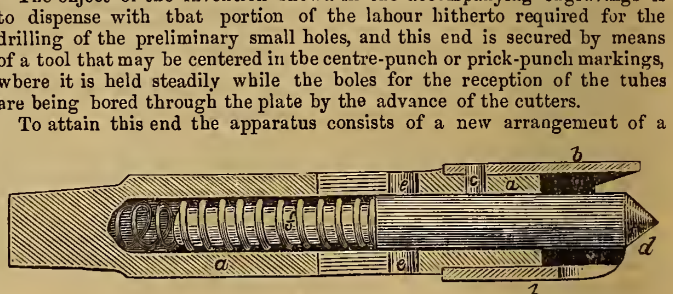


FIG. 1.

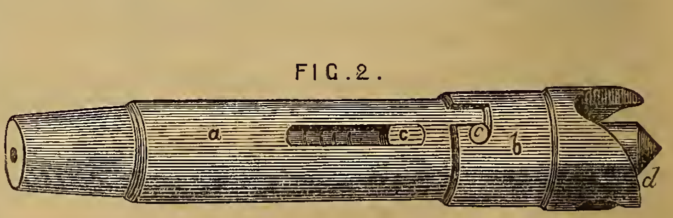


FIG. 2.

Fig. 1 is a longitudinal section of the same, and Fig. 2 is an outside view of the improved tool.

The socket, *a*, may be fitted to a machine in the usual manner. It carries a circular cutter, *b*, which is secured by the lantern lock-pin, *c*. This lock corresponds with the direction of the cutting of the cutter, so that it remains fastened when the drill is being used or being withdrawn, and may be readily unfastened by simply turning it back when it is required to move the cutter. The centre, *d*, is retained in the socket by the key, *e*, that works in a suitable slot, and it is pressed outwards by the spring, *f*, which should have sufficient force to resist any tendency to lateral displacement. When the tool is pressed towards a plate to be drilled, the spring yields, and the centre, *d*, remains in the centre-punch marking, while the cutter advances and passes through the plate.

By means, therefore, of the yielding centre in combination with the circular cutter, a circular disk may be cut at once from the plate instead of first drilling a small hole and then cutting away all the rest of the metal with an ordinary pin drill. A single socket may be fitted with several sizes of cutters made with offsets, as may be required.

## PATENT LAW.

Numerous and, as we consider, just complaints are constantly being brought against the present defective state of the law with regard to Patents. In some instances these defects are most glaring, and, as might be expected, are to be found where the litigation has been most protracted. In order to establish our position, we will give some illustrations drawn from a few of the most celebrated infringement cases, and consequently begin with :—

### The Bovill Litigation. (No. 1.)

In the following narrative of the litigation arising out of the late Mr. G. H. Bovill's patents of 1849, for improvements in the manufacture of wheat and other grain into meal and flour, we shall in all instances give the very words of the judges, and shall expose ourselves to the imputation of being prolix in quotation rather than deserve the suspicion that we suppress the context by which their expressions might have been made less obscure or startling.

Mr. Bovill had in 1846 obtained a patent for an improvement in the manufacture of flour, consisting in means for forcing air at higher than atmospheric pressure between the grinding surfaces of millstones by closing the eye of the top stone.

In an affidavit sworn in 1857, Mr. Bovill spoke of this invention in these terms, which it will be well to bear in mind :—

"The invention described in the last-mentioned specification was of great public utility, and was brought into general use; but it was found, in the process of grinding grain in mills made with the improvements described in that specification, a great quantity of the stive, or fine dust produced in the process of grinding, was carried with the plenum of air (forced by the blast between the millstones) into the chamber of the mill so as to occasion not only great loss, but to be very injurious to the lungs of persons engaged in the mill."

The patent of 1849 with which we are concerned was granted for four improvements, thus described in the original specification :—

"The first part of my invention consists in making the bed, or under stone, rotate instead of the upper one as heretofore practised.

"Secondly, in an arrangement for ventilating grinding surfaces of millstones, and the introduction of air through the top stone, when fixed, either by blowing or exhaustion.

"Thirdly, in exhausting the air from the cases of millstones, combined with the application of a blast to the grinding surfaces.

Fourthly, in separating the stive, or dust of flour, from the air when exhaustion or blast is employed to facilitate grinding and preventing the dust and waste in the mill."

The formal claims were in these terms :—

"What I claim is: First. Making the bed stone rotate instead of the top one, as heretofore practised.

"Second. Fixing the top stone and causing currents of air, either by exhaustion or pressure, to pass between the grinding surfaces of millstones when the top stone is so fixed, and in the introduction of the ventilating pipes in the stones as herein described.

"Third. In exhausting the dusty air when the same has been blown through the grinding surfaces of the millstones from the stone cases or chambers receiving the meal, as herein described.

"And, lastly, I claim the passing of the dust or stive caused in the process of grinding through suitable porous fabrics by which the flour is filtered from the air, as herein described."

We must quote further the practical directions for carrying out the third part of the invention.

"In carrying out the third part of my invention when working mill stones with a blast of air, I introduce a pipe to the mill stone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber, as hereafter described, by which the dust in the mill is avoided, and the grinding improved. And this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the mill-stones without a blast, this having before been practised as above-mentioned"—which refers to a preceding passage in these words, air has also been exhausted down through the eye of the top stone when running, and between the grinding surfaces—I do not therefore claim this principle, except when worked in combination with a fixed upper stone."

The earliest recorded proceedings in reference this patent, are contained in some papers printed by order of the House of Commons, in April 1853, on the motion of Mr. Raikes Currie. These papers contain notes of a series of trials at Her Majesty's Steam Mill, in the Royal Victualling Yard, Deptford, commencing in April 1847, and concluding in September, 1852. The country has remained in sad ignorance of the benefits Mr. Bovill's improvements have secured to the milling trade as reported upon at the close of these trials. The saving per quarter by use of his improvements was stated to be about 2s. 6d., and the reports secured for Mr. Bovill, a royalty of 6d. per quarter. The value of a series of trials like these is reduced very low by observing that Mr. Bovill, in December 1852, offered to take the Deptford mill into his own hands, and to manufacture the Government corn with his machinery at about 3s. per quarter, whilst in February 1847, he had stated in a letter to Captain Sir John Hill, that "the cost of grinding wheat is admitted by all millers to be about 2s. per quarter."

This is not the time to enter upon a detailed examination of the various particulars shown in these papers. We are concerned with the litigation, and notice the Deptford trials only because they have had so marked an influence upon much of that litigation.

In May 1855, Mr. Bovill, filed a disclaimer of the first part of his invention, as he had been "informed and believed that the making the bed or under-stone rotate instead of the upper one, was not at the date of his letters patent a new invention," Thus the inventions or parts of the invention undisclaimed became parts 1, 2 and 3, instead of parts, 2, 3 and 4.

The first actual litigation was the action of Bovill *v.* Keyworth and Selley, tried at the Guildhall, before Lord Campbell, and a special jury, on the 4th and 5th of July 1856. Neither this nor any other action seemed to have been for infringements of this invention (now No. 1) of fixing the top stone &c. The one complaint in this action was for infringement of claim No. 2. (originally No. 3) for using an "exhaust in combination with a blast," and in his opening address the nature of the question for trial was thus distinctly explained by Mr. Bovill's counsel.

Mr. Knowles, Q.C. (for the Plaintiff) : I shall not contend that a Blast or an Exhaust is new.

Attorney General, (for the Defendant)—nor so applied to this particular purpose,—we say that the Blast for introducing the current, and the Exhaust for withdrawing it are old, and that the combination is also old.

Mr. Knowles : I believe for this purpose a blast is new—at any rate the combination is new.

The Attorney General : That is the issue.

We give some further extracts from the short hand notes of this trial, so that the final judgment may be better appreciated.

In examination by his own counsel, Mr. Webster, Mr. Bovill was asked :—

Q. Does the obstruction of the interval between the stones by the meal being ground occasion a great difficulty in getting the air through ?—A. Very great.

Lord Campbell : Both sides are agreed on that.

Mr. Webster : Was the conclusion, if you mean to introduce air successfully, that it should be above the pressure of the atmosphere ?—A. Yes. You want a powerful pressure to overcome the friction, or rather the holding power of the stones, to drive out the flour from between the surfaces fine enough to escape between the surfaces. Unless you had that power, you could not do it.

Lord Campbell : Considerably above the atmosphere ?—A. Yes ; considerably. The ventilation is not sufficient. It requires a powerful force of air.

In cross-examination by the Attorney-General : At the very last trial (Bovill *v.* Pimm, which was on the Patent of 1846) was not the thing tried in court with a model made from the specification of Mr. Gordon (who had a patent of 1844 for the cold blast) ?—A. It was the most ingenious mechanical lie that was ever constructed in a Court or put in practice.

The Attorney-General : Don't laugh about it, sir ; it is a serious thing.—A. It is really a mechanical lie.

Q. In what respect ?—A. In this respect :—that the air was so deflected by that model between two spaces which had no obstruction through them. Now, in a millstone, that is filled with meal, and that requires about half a ton of pressure of the millstone holding the meal together, no air could pass from that model so constructed; if the surfaces had been filled with meal and a pressure of half a ton weight had been applied, no air could have escaped. But there was nothing between them; they were somewhat apart, and this model was ingeniously constructed to deflect the air that passed between the surfaces.

The Attorney-General: Am I to understand you that, in working your exhaust, you draw in no air?—A. We regulate as near as we possibly can that none shall be drawn it.

Q. What I want to know is, whether you can so regulate it that no air can be drawn in?—A. All that we require to do is to determine the current, precisely as a chimney in a room prevents the room smoking.

Q. But, without having recourse to that illustration, what I want is your answer to this question: Can you so regulate it as that the exhaust shall simply act as an exhaust, and not be the means of introducing any current of air contributing to assist the blast?—A. Clearly. There is no valve in the meal spout. There is a free access. It is not clogged in any way.

Q. That is the very thing that makes me ask the question. The blast is, according to your theory, to introduce currents?—A. Between the stones.

Q. And the exhaust is to draw it out?—A. Clearly.

Q. I want to know whether the exhaust, in addition to drawing it out, does not contribute something towards drawing it in?—A. Oh! no.

Q. You are sure of that?—A. Yes; the meal spout is perfectly open. Of course, air will go where it can most easily go. If the meal spout is open to allow a volume of air to go in, it is clear that it would go through there instead of down the obstructed passages, which require, as I have described, a great pressure to get it through.

Q. The blast does go through, does it not?—A. Of course it does. It requires the force of the blast to go through.

Q. What I want to know is, whether the exhaust in drawing out the air that is there, does not contribute to its entrance?—A. It may to this degree, by remitting the obstruction of the plenum; and, therefore, it does contribute by removing that plenum, instead of the blast having otherwise to encounter the pressure in the meal case.

Q. Then, if I understand, you would require a less amount of power in your blast, in consequence of the exhaust creating a vacuum through which the air introduced by the blast will escape?—A. There is no vacuum.

Q. Supposing the blast was not at work, there would be a vacuum from the exhaust, would there not?—A. No.

Q. If anything draws out air, unless the air is replenished there will be a vacuum?—A. The meal spout admits it freely. Here is a large spout down here, down which the meal comes, which communicates with this case; and, if you have an exhaust here, you may keep sucking away to all eternity, but there is no vacuum. If you put a valve in here as Newton does, then you get a vacuum in that case.

The Attorney-General (now Lord Chief Justice of England) ended his speech on opening the defendant's case thus:—

I will just observe, gentlemen—although that is rather matter for my Lord, that the claim here is not, as represented, a claim for a combination, but that it is a claim for each of these parts, as well as for the combination of the whole; and, therefore, if I show you that either of them was old—either the blast or the exhaust—the defendants would be entitled to your verdict.

Lord Campbell: There is no doubt the blast process was old. I mean, *per se*.

The Attorney-General: If I show the exhausting process to be old, which I shall do, then the patent cannot stand any more than if I show, as I will do, the combination to be old also. Then I shall submit that that will remain for the witnesses to establish. You will have evidence laid before you that, although the plaintiff professes that the exhaustive process—the sucking away—adds nothing to the blast, that this is not so, that it does add to the blast, and that in the defendant's machinery it is used for the purpose; which again would be a distinction between the plaintiff's machinery and the defendant's.

Lord Campbell: I think you are mixing water with your wine.

The Attorney-General: Perhaps so, my Lord. (And then the witnesses were called.)

Lord Campbell at the close of his summing up, thus stated the questions the jury had to decide.

"You will consider whether Mr. Bovill was the inventor of this process of the combination of the blast and exhaust, or whether he took it from Dive's man; the second question is whether this process was known and used before Mr. Bovill's patent in June, 1849; the third is, whether this process has been infringed by the defendants, whether they have used the same or what is substantially the same; And if you answer all these questions in the affirmative, you will then have to determine what will be the amount of damages.

When the jury retired to consider their verdict, Mr. Atherton the defendant's counsel addressed the judge thus:

"I wish to put two questions, which I think my learned friend the Attorney-General mentioned upon the specification, and on which there is no disputed fact—the first is this—that the fixed upper-stone having regard to the terms of the plaintiff's specifications is an essential part of the plaintiff's invention. If that be so, then there is no infringement inasmuch as we use the rotating upper stone."

Lord Campbell: Just repeat your objections.

Mr. Atherton: First I say that the fixed upper-stone is an essential part of the invention and specified, then the next is that the specification is not for any manner of new manufacture, but for a general combination of any exhaust with any blast.

Lord Campbell: You say that it is bad on the face of it?

Mr. Atherton: Yes my Lord. If you will reserve these points in the event of the verdict being in favour of the plaintiff.

Lord Campbell: There cannot be any objection Mr. Knowles to these points being reserved.

The jury found a verdict for Mr. Bovill on all the questions submitted to them, but it will be observed those questions did not include anything in relation to the novelty or utility of the 1st or the 3rd claim or the sufficiency of the specification. A conditional rule for a new trial was obtained by the defendants.

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## LAUNCH OF H.M.S. TURRET SHIP "CAPTAIN."

This vessel which has given rise to so much controversy, was floated out of Messrs. Laird's dry dock at Birkenhead, on the 27th of March. The following are some of the principal dimensions:—Length over all 335ft.; ditto between perpendiculars, 320ft. breadth extreme, 53ft. 3in.; do. moulded 53ft.; draught of water aft 23ft, 6in. do. forward, 22ft. 6in. The *Captain* is fitted with twin screws 17ft. diameter, each screw being driven by an independant pair of trunk engines; the collective nominal H.P. being 900 with the usual Admiralty stipulation to work up to six times that amount. The engines are fitted with surface condensers, and the four cylinders which are each 80 inches effective diameter, and 3ft. 3in. stroke have steam jackets. The steam is supplied by eight boilers having a total of 28 furnaces; the coal bunkers can carry 610 tons of coal, and her speed is estimated at 14 knots. The armour plating extends all round the ship, from a depth of 5 feet 6 inches below the water line up to the turret-deck, which is 8 feet above the same. The lowest strake is $6\frac{1}{2}$-inch, the remainder, for a length of 40 feet opposite each turret, 8-inch, and on the space between the turrets 7-inch. The thick plating in wake of the turrets is gradually reduced to 4-inch and 3-inch at the stem and stern respectively. The two turrets are protected with 10-inch armour and 13-inch backing. Behind the armour on the side of the ship comes a 12-inch teak backing, and an iron inner skin $1\frac{1}{2}$ inch thick formed of two $\frac{3}{4}$-inch plates supported by framing 10-inch deep. In order that she may make better weather at sea the *Captain* has been fitted with a poop and forecastle, connected by a hurricane or spar deck, like many of the Atlantic steamers. From this deck, which is 24 feet wide, and about 20 feet above the water, the sails of the ship will be worked when she is under canvas. Her armament is to consist of six guns, each turret having two 600-pounders, and a 100-pounder being carried under the poop and under the forecastle. The position and calibre of these last two guns is, however, not yet definitively settled. The turret-guns are 11 feet 6 inches above the water line, and their arcs of training are as follows:—In the foremost turret both guns will train forward to an angle of 23 deg. with the middle line, and aft to 25 deg.; while one gun will train forward to 16 deg. and aft to 6 deg. with the same. In the after turret both guns will train to 15 deg. forward and 25 deg. aft; and one gun to 6 deg. forward and 18 deg. aft. But it must be borne in mind that this is merely the theoretical training of the guns as shown by the drawings.

It has been stated, by Captain Symonds, in a paper read before the United Service Institution, that, in order to obtain the fire from the after turret of 6 deg., the shot from the gun has to pass over 156 feet of deck, and between the legs of the tripod masts—a state of things which would be obviously dangerous in an action. The *Captain* is to carry a complement of four hundred men, but she has messing room for six hundred in addition to officers, and there is also ample accommodation for an admiral and his staff. Her contract price is 276,500*l.* for hull, and 58,500*l.* for engines, making a total of 335,000*l.*; to this amount, however, the cost of armament, rigging, and stores has to be added. As already mentioned the poop and forecastle are connected by a hurricane deck, and the hatchways amidships, which are of iron, are carried up to it, forming both a support and ensuring a good system of ventilation. Doors are fitted in the iron bulk-heading to give access to the main or turret deck, but in bad weather these will be closed, the hatchways in the poop, forecastle, and hurricane deck being left open. In consequence of the small size of the ports, the guns are to be sighted from the tops of the turrets, and arrangements are made to protect the gunner's head while taking aim.

It has been the ill fate of the turret system to be associated from the first with representations which are not substantiated by fact, but which are attributable to the undue enthusiasm of its advocates. Captain Coles's original idea of putting a gun upon a turntable, and surrounding it with armour, was undoubtedly the origin of a very great invention. This idea, combined with another conception of his, of mounting a gun upon a raft, and embodied in a low armour-plated vessel like the Monitor, gives us the most striking specimen of a perfect ship of war, either for purposes of coast defence, or for attacking hostile ports in inland waters, or during fine weather. It is the system of all others in which we can obtain the maximum both of offensive and defensive powers; but it does not follow that such a vessel is the best for cruising and sea-going purposes. With a free-board of two or three feet, the Monitor is unquestionably the steadiest form of vessel that can be devised; but when the free-board is increased to seven or eight feet, as in the *Captain*, the steadiness of platform is lost. If we wish to have a thoroughly efficient sea-going ship of war, it is absolutely necessary that her guns shall be high out of the water. This can be obtained, as in the Monarch, by carrying up the sides of the vessel like those of a broadside ship, and by placing the turrets on the upper deck. In such a case we either have a comparatively weak side, or we must give the vessel additional beam and draught of water in order to obtain sufficient displacement to carry thicker armour. Both these plans are objectionable. The problem can, however, be solved in another way, by building round the base of the turrets an armour-plated breast-work, as in the Ceberus, a monitor recently built for the defence of Melbourne harbour, We then have a vessel which, owing to her low deck, possesses all the steadiness characteristic of the Monitor type, and which at the same time is practically secure from foundering, owing to the openings in the deck being enclosed by the breast-work. We get, too, by this means, that all-round fire which distinguished Captain Coles's early plans, but which cannot be said to form a feature of the *Captain*. But if this all-round fire is to be perfect, we must sacrifice to it the ship's masts and rigging. Is it right, then to make the safety of a vessel entirely dependent upon her engines? This is a question for naval men to answer; but if they will not object to take such a ship to sea, then the twin-screws come to our aid, and these, combined with great coal-carrying power, as in the new turret-ships described by Mr. Childers in his speech on the Navy Estimates, will enable us to produce a monitor suitable for cruising and sea-going purposes, at least for European warfare. For by using twin-screws we can employ engines of more moderate power, and therefore less likely to break down, and if any accident should happen to one screw or shaft, we should always have a reserve of power in the other sufficient to bring the ship safely to port. There can be no doubt that Captain Coles has been much fettered in his design by having to fit his ship with sails, and in spite of the great ingenuity which he has displayed he has, as we have seen, had to sacrifice his all-round fire, and he has also had to give his vessel a hurricane deck, which some critics maintain is too small to admit of properly working the sails, while others declare that it is likely to be injured by the explosion of the turret guns, and we fear that there is too much foundation for both of these objections.

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## INTITUTION OF NAVAL ARCHITECTS.

### THE IRON FLOATING DOCK OF CARTHAGENA, ITS PROPORTIONS AND RELATIVE STABILITY.

By GEORGE B. RENNIE, M.I.C.E., Assoc.

The form of this dock may be briefly described as an oblong rectangular box or trough, without a top or ends, the walls and bottoms of which are hollow, and divided into several independent chambers. The vessel to be docked is placed between the side walls, and is raised completely out of the water by the buoyancy of the bottom of the dock. The side walls act as floats to prevent the dock sinking too rapidly, eventually from being entirely submerged.

The operation is performed in this way, water is allowed to flow into the different compartments forming the base, by means of sluices, and distributing pipes; the dock then gradually sinks, until the buoyancy of the chambers, forming the side walls, becomes equal to the weight of the entire structure; that is, when it is desired to sink the dock to its greatest depth for the purpose of taking in the deepest draught ship the dock is intended for, for vessels of less draught it is only allowed to sink to a depth sufficient for the particular vessel. The vessel is then hauled in between the walls, and the engines and pumps of the dock set to work to discharge the water from the bottom or base; when empty, it is capable of sustaining a weight of ship (less the weight of the dock), equal to the total displacement of the bottom or base.

The vessel is shored up in the usual manner adopted in the ordinary graving dock. The dock is entirely of iron, with the exception of the decks, shoring steps or alters, and fenders, which are of timber. It is strengthened both longitudinally and transversely by bulkheads, which form the division of the chambers, as well as by intermediate lattice framing, which give the structure great stiffness.

The dock for Carthagena was commenced in 1859, sent out in pieces from England, and erected at Carthagena in a shallow basin prepared for the purpose, and when completed water was let into the basin and the dock floated out. When first floated, it was found to have an uniform draught of water of 4ft. 7in.; this gives a total displacement of 4,400 tons of sea water, which is equal to the weight of the dock complete.

Some of the largest vessels which it has raised are the frigate *Princessa d Asturias*, of 3,810 tons, and 21ft. draught of water, the frigate *Villa de Madrid* of 27ft. 6in. draught, weight unknown, the ironclad *Saragoza*, of 4,973 tons, and 55ft. draught, and the ironclad ship *Numancia*, of 5,600 tons weight, and 24ft. 1in. draught, this latter vessel remained supported for eighty days, without causing any damage to or undue straining of the dock. The weight of this ship was further tested by the depth of flotation of the dock as observed with the ship on it; this was ascertained to be 11ft. 3in., giving a total displacement of 10,800 tons of sea water; but on examination of the different chambers it was found that there was about 7½in. depth of water in the lower ones and 7¼in. in the middle ones, equivalent to 800 tons weight; this added to the weight of the dock, 4,400 tons, gives 5,200 tons, leaving 5,600 tons as the weight of the ship.

The dimensions of the *Numancia*, the largest of the above named vessels, are as follows; length (perpendicular), 316ft.; extreme breadth, 57ft.; displacement at load draught, 7,420 tons.

The dimensions of the dock are as follows: length, 320ft.; breadth outside, 105ft.; ditto inside, 79ft.; height outside 48ft.; ditto inside, 36ft. 6in. If the few inches of water remaining in the base and middle chambers were entirely removed, the draught of water of the Carthagena Dock, with such a vessel as the *Numancia*, of 5,600 tons weight, would be 10ft. 6in.

The main proportions of the dock are as follows: the length is between 3 and 3¼ times the breadth. The width between the walls at the top is ¾ of the breadth. The floor of the dock is ½ the breadth. The height of the side walls is somewhat under ½ the breadth. The depth of immersion $\frac{1}{10}$th of the breadth.

These proportions are suitable for almost all sizes of floating docks of the rectangular form. Thus, supposing a dock to be made capable of lifting and sustaining a vessel like the Achilles, of say 10,000 tons weight, the breadth would be 120ft., the length 400ft., the width inside 90ft., the "floor" 60ft. in width, and the immersion 12ft.; total displacement, 16,457 tons.

In calculating the height of the metacentre, or the greatest height the weights may be raised above the centre of displacement of the immersed body at an angle of inclination, say of 10 deg.; and taking the distance between the centres of gravity of the immersed and emersed portions due to the inclination at two-thirds the total breadth, and multiplying by the portion immersed and dividing by the total volume immersed into the sine of the angle of inclination, it will give 90·75ft. for the distance of metacentre from the centre of gravity of the volume immersed, or 85·5ft. above the line of flotation for the Carthagena Dock, whereas the centre of gravity of the entire structure and ship is calculated to be only 18ft. above the line of flotation, allowing for a ship of 26ft. 6in. draught of water on keel blocks 4ft. in height.

In the dock proposed, the metacentre is 101·5ft. above the centre of gravity of displacement, or 95·5ft. above the line of flotation, and the centre of gravity of the dock with the Achilles, is calculated to be only 19ft. 3in. above the line of flotation. In calculating the amount of statical stability of the dock at Carthagena with an immersion due to the weight of such a vessel as the *Numancia*, of 5,600 tons, it is found that, supposing the inclination to be 10 deg., that the moment of stability will be 360 when reduced to feet and tons per foot in length of the dock, or a total of 118,080 tons for 320ft.; and the dock proposed would have a moment of stability of 549.2 when reduced to feet and tons per foot in length, or a total of 219,680 tons for 400ft. This is nearly as the cube of the breadth, and directly as the length.

Comparing this latter with a dock of a U-shaped section, with water ballast, like that actually made for Bermuda, as calculated from a lithographic drawing giving the particulars of this dock, it is found that the moment of stability equals 660 foot-tons per foot in length, or for the length of 333ft., a total of 219,780 foot-tons, or about the same as the one proposed, of a rectangular form.

A further comparison of the dimensions, weight of ship to be docked, height of metacentre of these two forms of docks, may not be without interest:

| | U-shaped Section. | Rectangular Section. |
|---|---|---|
| Available length of dock for the largest ship ... | 333ft. | 400ft. |
| Extreme outside breadth.......................... | 123ft. 9in. | 120ft. |
| „ inside „ .......................... | 85ft. | 90ft. |
| Breadth of "floor" .............................. | 50ft. | 50ft. |
| Draught of water with heaviest ship ........... | 40ft. | 12ft. |
| Area of immersed section ditto ..................... | 4000 sq. ft. | 1440 sq. ft. |
| Greatest weight of ship capable of being docked | 8,000 tons | 10,000 tons. |
| Weight of dock.................................... | 8,350 tons | 6175 tons. |
| Centre of displacement below line of flotation | 18ft. | 6ft. |
| Distance of metacentre from centre of displacement .............................................. | 38ft. 6in. | 101ft. 6in. |
| Distance of centre of gravity from centre of displacement ............................................ | 5ft. | 25·3ft. |
| Centre of gravity above or below line of flotation ...... . ...... .................................. | 13ft. 3in. below | 10ft. above. |
| Moment of stability per foot in length of dock | 600 tons | 549·2 tons. |
| Total for whole length of dock..................... | 219,780 tons | 219,680 tons. |
| Draught of water to take in a ship of 26ft. draught with keel blocks 4ft. in height....... . | 50ft. | 15ft. |

From the above comparison, it will be seen that a dock of rectangular form of the same proportions as that of Carthagena, will have the same total stability as the U form of dock, require about one-fifth less material for its construction, and be capable of supporting a longer ship of one quarter greater weight, and with less draught of water. Moreover, the arrangements for docking are less complicated; for when the ship is once on the keel blocks, pumping is the only operation to be perform as there are neither gates nor caissons to close in the ends.

To represent the relative stability of different forms of section in a clear and simple manner (although not so accurately as may be found geometrically or mathematically), the following Table is compiled from experiments on different sections made of thin copper, to a scale of 10ft. to the inch. The models were all 9in. long; the leverage was taken at 8in. from the central line of the model. The lead weights representing the ship were cylindrical, and supported on their axis, at a distance representing the height of the centre of gravity of the ship, above the floor of the dock of 27ft. 6in.

The model E represents the Carthagena Dock, with its angles of inclination, and with the same weight and leverage as the other models.

Although it may be seen from this that other forms may have a stability equivalent to that of the rectangular or flat form, it can only be done by the addition of a considerable amount of water ballast, which so increases the draught of the dock as to necessitate the ends being closed in.

The Carthagena Dock, as before mentioned, was sent out from this country in pieces, and erected in a shallow basin made for that purpose, at Carthagena; this on the whole (when practicable) seems the most safe and simple plan, and the basin is moreover available when required for taking in the floating dock for the purpose of cleaning, painting, or repairing. Wooden floating docks of somewhat similar section to that of Carthagena have been towed to their place of destination, as was the Pola Dock, from Venice, the Havannah Dock, from New Orleans, and more recently, that of Alexandria, from the South of France, but the square ends of the form are no doubt ill adapted for being towed through the water. In order to meet this difficulty, when it was contemplated to tow a dock across the Atlantic, a modified arrangement of the rectangular form was proposed by Messrs. Rennie better adapted for being towed throught the water. The side walls were to be reduced to about two-thirds of the length of the floor of the dock, the rectangular ends of the floor to have been rounded off so as to form pointed ends, upon which temporary sides were to be raised to the required height, in order that the dock might be decked over from end to end; this deck, together with the temporary sides, would have to be removed on arrival at its destination.

Considering the length of the voyage, it was thought that the empty space below the deck might be avilable for the stowage of coals and other stores to supply (during the voyage) the steamers employed to tow the dock out. This

*Table of Experiments on the Stability of Floating Docks, made on Models to a scale of 10ft. = 1in:*

| FORM OF SECTION. | Weight of model in ounces. | Weight representing ship in ounces. | Approximate proportion of dock to ship. | Breadth of model to scale in feet. | Height of centre of gravity of ship from floor to scale in feet. | Degrees of inclination with weights, at a leverage of 8in. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1oz. | 2oz. | 8oz. | 8oz. |
| | | | | ft. in. | ft. in. | deg. m. | deg. m. | deg. m. | deg. m. |
| | ... | 0 | ... | ... | ... | 0 35 | 1 29 | 3 3 | 7 7 |
| A ⊔ | 48½ | 49½ | 1 : 1 | 120 0 | 27 6 | 0 52 | 2 11 | 3 57 | 9 6 |
| | ... | 73½ | 3 : 2 | ... | ... | 1 29 | 2 35 | 4 35 | 10 6 |
| B U | ... | 0 | ... | ... | ... | 0 31 | 1 12 | 3 49 | 5 50 |
| | 42 | 49½ | 1 : 1 | 127 6 | 27 6 | 0 24 | 0 59 | 3 26 | 5 36 |
| With water ballast | ... | 73½ | 5 : 3 | ... | ... | 0 21 | 0 55 | 3 6 | 4 14 |
| C ⊔ | ... | 0 | ... | ... | ... | 0 55 | 1 29 | 3 53 | 8 22 |
| Without water ballast | ... | 97½ | 1 : 1 | ... | ... | 0 58 | 1 57 | 5 9 | 10 6 |
| " " | 48½ | 73½ | 3 : 2 | 120 0 | 27 6 | 1 57 | 3 5 | 5 43 | 12 8 |
| With water ballast | ... | 0 | ... | ... | ... | 0 52 | 1 26 | 2 45 | 6 28 |
| " " | ... | 49½ | 1 : 1 | ... | ... | 1 16 | 2 7 | 3 22 | 8 18 |
| " " | ... | 73½ | 3 : 2 | ... | ... | 1 57 | 3 9 | 4 45 | 9 19 |
| D ‿ | ... | 0 | ... | ... | ... | 3 43 | 6 51 | 14 34 | |
| Without water ballast | ... | 73½ | 3 : 2 | ... | ... | 2 28 | 3 53 | 7 28 | |
| With water ballast | 48½ | 0 | ... | 120 0 | 27 6 | 1 43 | 3 23 | 7 24 | 14 2 |
| " " | ... | 49½ | 1 : 1 | ... | ... | 1 23 | 2 27 | 5 9 | 10 2 |
| " " | ... | 73½ | 3 : 2 | ... | ... | 1 23 | 2 51 | 5 36 | 10 32 |
| E ⊔ | ... | 0 | ... | ... | ... | 0 31 | 1 33 | 3 37 | 8 5 |
| " | 30½ | 49½ | 5 : 3 | 105 0 | 27 5 | 1 26 | 2 35 | 5 43 | 12 15 |
| " | ... | 73½ | 7 : 3 | ... | ... | 2 11 | 3 2 | 7 7 | 14 48 |
| | ... | 0 | ... | ... | ... | 6 22 | 12 48 | | |
| F U with water ballast | 32 | 49½ | 5 ; 3 | 80 0 | 27 5 | 9 19 | 14 52 | | |
| | ... | 73½ | 7 : 3 | ... | ... | 7 14 | 12 31 | | |

In the above Table, A and B represent sections of docks, of the form proposed and that actually executed. It will be seen on comparing the inclination of these two forms with the same weight and leverage, that B, the U shape, gives greater stability per unit of length than A the ⊔ shape, but as the model U was made by mistake to represent 127ft. 6in. in breadth instead of 123ft. 9in., the relative stability as shown by the angle of inclination is somewhat greater than calculation indicates.

The model C shows how the stability of the same form of section may be increased, by the addition of water ballast at the bottom.

The model D of a segmental form may, with the addition of water ballast, have nearly a stability equivalent to the form A.

form of dock would not have required a basin as at Carthagena, and the necessary repairs could have been effected by means of a rectangular iron box lowered under the dock, and placed against the defective part, and the water pumped out from within it. The joints between the box and the bottom of the dock being previously made water-tight by means of an elastic substance, or the water kept out by a pressure of air, which, in this case, would not have exceeded 3lb. per square inch.

In conclusion, it is considered that floating docks of the form and proportions to that of Carthagena will have ample stability for the heaviest ship to be docked.

That it is of the simplest construction.

That the smallest amount of material for a given strength and stiffness will be used in its construction.

That the cost will be less than for other forms of sections.

That the simplest docking arrangements and safety of the dock are best attained by that form.

And lastly, that by the modification suggested in the paper, they may be towed with comparative safety to any part of the world.

## ON THE CALCULATION OF THE STRESS IN PROPELLER SHAFTS

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1. Through a long series of practical trials extending over many years it was ascertained by Lieutenant David Rankine (h.p. Rifle Brigade), and by the author of this paper, that the greatest stress which the wrought iron axles of very smooth running railway carriages, travelling at speeds not exceeding twelve miles an hour, would safely bear, when made of the best materials and in the best way, was 9000lb. on the square inch (or about 6.3 kilos. on the square millimetre). Any defect in materials or workmanship when exposed to that stress was always found to cause the axle to give way in the end, though sometimes not until it had run for more than three years. The immediate breaking stress was not directly ascertained, but it is probable that the factor of safety, was between five and six. A greater factor of safety or, in other words, a smaller limit to the intensity of stress, is of course required when the motion is rougher than it was in those carriages.

2. According to the ordinary method of calculating the greatest stress in propeller shafts, the moment of the twisting action upon the shaft is alone into account; and when that method is applied to examples taken from actual steam vessels, results are obtained approaching very near to the limit already stated. For instances, 8,000lb. to the square inch is a not uncommon value of the intensity of the stress in a propeller shaft, as calculated from the twisting action alone.

3. But the real intensity of the stress is greater still, for with the twisting action there is always combined more or less of a bending action, produced partly by the weight of the shaft and partly by its reaction when the vessel pitches and heaves with the waves. The object of the present paper is to give rules for calculating the total or resultant stress produced by the twisting and bending actions combined, and to illustrate them by an example.

4. *Twisting Action.* The greatest twisting moment is to be calculated from the indicated horses' power of the engines, as follows:—Multiply the power by 33,000, in order to reduce it to foot pounds per minute, and divide the product by 6·2832 times the number of revolutions of the shaft per minute. The quotient will be the mean twisting moment in foot-pounds (for kilogrammetres the multiplier is 4,500 instead of 33,000). The greatest twisting moment in a ratio which may be estimated at about 1·6 for a single engine, 1·11 for a pair of engines with cranks at right angles, and 1·05 for three engines with cranks at equal angles.

When British measures are employed, the greatest twisting moment having been computed in foot-pounds, is to be multiplied by twelve to reduce it to inch-pounds.

To find the greatest intensity of the stress produced by twisting, multiply the greatest twisting moment by $\frac{16}{\pi}$ (= 5·1 nearly), and divide by the cube of the diameter of the shaft. In symbols, let M be the moment, $d$ the diameter and $q$ the twisting stress (as it may be called).

$$\text{Then, } q = \frac{5{\cdot}1\ \text{M}}{d^3} \quad \ldots\ldots\ldots\ldots \quad (1)$$

5. *Bending Action.* The greatest stress produced on the particles of a horizontal cylindrical shaft by the bending action of its own weight, is equivalent, to the weight of a column of iron, whose height is a third proportional to the diameter, and the span between the bearings.

In symbols, let $l$ be the span between the bearings (in inches if British measures are used); $d$, the diameter; $w$, the heaviness of iron (= ·278lb. per cubic inch, or 7,690 kilos. per cubic metre); $p$, the greatest bending stress, as it may be called.

$$\text{Then, } p = \frac{w\ l^2}{d} \quad \ldots\ldots\ldots\ldots \quad (2)$$

The reaction of the shaft produced by vertical oscillation, as in pitching and heaving, bears the same proportion to its weight that half the extent of the oscillations bears to the length of a pendulum which keeps time with them. Let $m$ be that proportion; then the bending stress is increased to,

$$p = (1 + m)\,\frac{wl^2}{d} \quad \ldots\ldots\ldots\ldots \quad (3)$$

In a vessel that follows the vertical heaving of the wave $m$ is nearly the sine of the wave slope—say, 0·25 in extreme cases, and 0·125 in ordinary cases.

6. *Resultant Stress.*—The resultant stress due to the twisting stress $q$, and the bending stress $p$ combined, is found by a formula which has been demonstrated by writers on the internal equilibrium of elastic solids; that is to say,

$$s = \sqrt{\left(q^2 + \frac{p^2}{4}\right)} + \frac{p}{2} \quad \ldots\ldots\ldots\ldots \quad (4)$$

7. *Numerical Examples.*—In the following examples the results are not computed beyond four significant figures:—

| | |
|---|---|
| Indicated H.P. ………… | 5,500 |
| Multiplied by ………… | 33,000 |
| Divide by ………… 6·2832 | )181,500,000 foot, pounds per minute. |
| Revo. per min. …………54 | )28,890,000 quotient, nearly. |
| Mean twisting moment | 535,000 foot, pounds. |
| For a pair of engines mult. by | 1·11 |
| Greatest twisting moment | 593,850 foot, pounds. |
| Multiply by………… | 12 |
| | 7,126,200 inch, pounds. |
| Multiply by………… | 5·1 |
| Diameter 16½in. ……<br>Diameter ³ ………… } 4492 | ) 36,340,000 product. |
| Twisting stress $q$ = ………… | 8,090lbs. on the sq. in. |
| Span between bearings ……… | 25ft. = 300in. |
| Divide by diameter ………… 16½ | ) 90,000 square of span. |
| Third proportional ………… | 5,455in. |
| Multiply by weight of a cubic inch of iron ………… | 0·278lbs. |
| Bending stress by weight alone | 1516lbs. on the sq. in. |
| × estimated value of $1+m$, say | $1\frac{1}{8}$ |
| Bending stress by weight and reaction = $p$ ………… | 1704lbs. on the sq. in. |

*Resultant Stress.*

$$s = \sqrt{\left(q^2 + \frac{p^2}{4}\right)} + \frac{p}{2} = 8987\text{lbs. on the square inch.}$$

being practically equal to the greatest safe stress of 9,000lbs. on the square inch, mentioned in sec. 1 as applicable to smoothly running railway axles at low speeds.

8. It seems very probable that if the method of calculation now described were applied to actual examples of propeller shafts, many instances would be found in which the resultant stress reaches, or even goes beyond, the utmost limits consistent with safety; and it is therefore laid before the Institution for their consideration, and for that of shipbuilders and marine engineers in general.

9. *Rules for designing Shafts.*—The conditions which the diameter of a shaft ought to fulfil are expressed by the following equation, derived from equation 4

$$s^2 - sp - q^2 = 0; \quad \ldots\ldots\ldots\ldots \quad (5),$$

in which, for $s$ is to be put a safe working value of the resistant stress (say 8,000lbs. on the square inch, or 5·6 kilos. on the square millimetre), and for $p$ and $q$, their values in terms of M, $l$, $w$, and $d$, as given by equations 2 and 1 respectively. The equation then becomes of the *sixth order*, and it is to be solved so as to find $d$. This can be done by approximation only; and a convenient method of approximation is as follows:—Assume for $q$ an approximate value $q'$ somewhat less than that of $s$ (say $q' = 0{\cdot}9\,s$). Then calculate an approximate value $d'$ of the diameter from equation 1, viz.,

$$d' = \left(\frac{5{\cdot}1\text{M}}{q'}\right)^{\frac{1}{3}} \quad \ldots\ldots\ldots\ldots \quad (6)$$

Then calculate for $p$ an appropriate value $p'$, from equation 3, viz.,

$$p' = \left(1 + m\right)\frac{wl^2}{d'}; \quad \ldots\ldots\ldots\ldots \quad (7)$$

and from the approximate value of $p'$ calculate a second approximate value of $q$, as follows:—

$$q'' = \sqrt{(s^2 - sp')} \quad \ldots\ldots\ldots\ldots \quad (8)$$

Should this agree with the first approximate value $q'$, the approximate diameter $d'$ will answer; and should there be a difference, a second approximation $d''$ to the required diameter is to be computed as follows:—

$$d'' = d'\left(\frac{q'}{q''}\right)^{\frac{1}{3}} \quad \ldots\ldots\ldots\ldots \quad (9)$$

When, as is usually the case, the difference $q' - q$ is small compared with $q'$, the following formula for the second approximation is sufficiently near the truth:—

$$d'' = d'\left\{1 + \frac{q' - q''}{3q'}\right\} \quad \ldots\ldots\ldots\ldots \quad (10)$$

A third approximation might be found by repeating the process, but the second approximation will in general be found accurate enough for practical purposes.

Should $q''$ prove to be greater than $q'$, the correction in Equation 10 becomes negative: that is, the second approximation to the diameter is less than the first.

10. *Example of the Rule*:—$l$ = 300in. as before.

| | | |
|---|---|---|
| Twisting moment M .................. | 7,126,200 | inch-lb., as before. |
| Multiply by .............................. | 5·1 | |
| Divide by $q'$ .............................. | 7200 ) 36,340,000 | product. |
| First approximation, $d'^3$ = ............ | 5,047 | |
| Do. do. $d'$ = ............ | 17·15 | in. |
| Divide by $d'$ = ........................... | 17·15 ) 90,000 | = $l^2$ as before. |
| | 5,248 | third proport'nal. |
| Multiply by $(1 + m) w$ = ............ | ·313 | |
| First approximation, $p'$ = ............ | 1,643 | |
| Intended resultant stress $s$ = ...... | 8,000 | |
| Multiply by $s - p'$ = .................. | 6,357 | |
| Second approximation, $q''^2$ = ...... | 50,836,000 | |
| Do. do. $q''$ = ......... | 7,131 | lbs. on the sq. in. |
| First approximation $q'$ = ............ | 7,200 | |
| $q' - q''$ = ....................................... | 69 | |

Second approximation to required diameter:—

$$d' = 17{\cdot}15 \left\{ 1 + \frac{60}{3 \times 7200} \right\} = 17{\cdot}21\text{in.}$$

## ON AN INSTRUMENT FOR DETERMINING THE DEVIATION OF SHIPS' COMPASSES.

By W. F. Reynolds, Esq.

The rapid extension of iron shipbuilding which the present generation has witnessed has been accompanied by the development of a practical difficulty in the art of navigation, namely the deviation of the compass caused by the disturbing influence due to the magnetism of the ship's iron. This difficulty has been sought to be overcome in many ways, such as the introduction of permanent magnets and soft iron, the unequal painting of the compass card, &c. The magnetism of the ship's iron, however, depends a great deal upon the induction of the earth and frequently alters considerably, from changes of latitude, and from other causes; it is therefore almost impossible to make permanent corrections of the errors of the compass by artificial means.

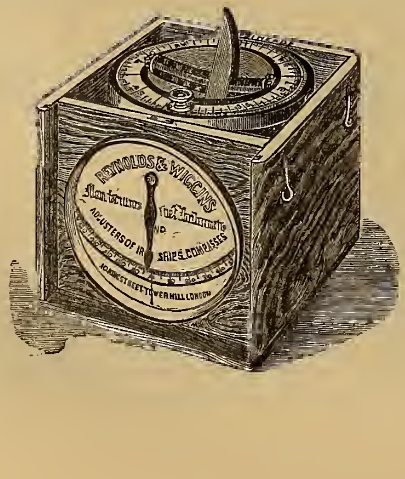
This being so, a ready appeal to a principle independent of all magnetic influences becomes desirable.

The true bearing of an object, either terrestial or celestial, being known, the actual position of the ship can be ascertained by the use of a compass or dumb card with a pair of sights in the case of terrestial objects, or by an azimuth compass in the case of celestial bodies.

The reference to the heavenly bodies, however, involves a consultation of tables or the time azimuth chart, &c.; this is a process which is found in practice to be but sparingly adopted by the officers of ordinary merchant ships, especially steamers, who, amid the pressure of other and manifold duties, are apt to depend too much upon the deviations as tabulated by the adjuster. It has consequently been thought that an instrument working somewhat on the principle of the sun dial will be found to be preferable, the sun's meridian distance being invariably known with sufficient accuracy to furnish the requisite data for an observation. It is to such an instrument that I venture to invite attention, and in placing it before the Institute, I wish it to be distinctly understood that I do not claim the credit of the first application of the idea, other instruments depending upon the same principle having already been made. These instruments, theoretically perfect in their construction, are, as I understand, practically defective when used under certain conditions.

When a ship has much wind on her beam there is an extent of heeling over which may seriously affect the compass, owing to the ship's deck not being parallel to the card (the plane in which it was adjusted.) As a clinometer must therefore be consulted before reliance can be placed upon any observation for determining the deviation, I have applied one to the instrument I am about to submit to your consideration.

The wind which causes the heeling over also affects the steadiness of the action of instruments exposed to its influence. The Palinurus, as I have named my instrument, is not affected by such a disturbing force, as the whole apparatus is flush with the top of the box in which it is contained; the heeling over of the ship causes the weather side of the box to be raised, and that, of course, completely shelters the working parts from the action of the wind.


REYNOLDS & WIGGINS
Manufacturers
AND
ADJUSTERS OF IRON SHIPS COMPASSES
10 KING STREET TOWER HILL LONDON

The mechanism of the instrument is very simple. It consists of a hollow half sphere, around the outer edge of which a plate containing the points and degrees of the compass (the vernier for which is on that edge of the box which is placed towards the ship's head); this plate is so fixed as to be capable of being moved (by means of the milled head) partially round the bowl. A segment of the inner edge of this plate is divided into degrees, the vernier for which is on the top edge of the bowl, so that, by turning the milled head, the plate may be set magnetic, and the bowl and hour circle—as it may be called—true. This corrects for the variation. The hour circle is deprived of its upper half, as it would hinder the shadow from falling on the lower half, especially when the sun has but little declination. It is slung by its ends, which are at right angles to the vernier on the bowl, in such a manner as to sweep the inside of the latter. Fastened to the centre of the hour circle is a sector, the upper edge of which forms a line with the vernier on the top edge of the bowl when the instrument is set for 0° latitude.

At each end of the sector is a socket to carry a pair of sights, which are required when the sun is not bright enough to cast a shadow, or when observing the moon or a star, the tail of the sight being always placed at the meridian distance on the hour circle. By placing either end of the sector upright, and setting the tail of the sight at O, the instrument may be used for taking ordinary bearings. The whole apparatus revolves upon a centre, and is hung in gymbals with a balance weight beneath.

As already mentioned, there is a clinometer on the side of the box facing aft. The following are the instructions for using the instrument.

1. Set for variation by turning the screw at the south point.
2. Set the latitude pointer to ship's latitude at time of observation.
3. Find the apparent time at ship (say within 5 minutes), and turn the instrument by means of the knobs at east and west, until the shadow of the edge of the sector cuts the time on the hour circle.

The point now at "Ship's Head" is the course the ship is on (magnetic), the difference between which and the binnacle compass is the deviation of that compass on that point. A pair of sights are supplied which can be fitted to either end of the sector, for the purpose of taking bearings of the moon and stars, or the sun, when not bright enough to cast a shadow. When using them (having set the latitude pointer), set the tail piece to the time on the hour circle, and turn the instrument as directed in rule 3, until the object is observed through the slits.

In high latitudes, and also when using the sights, it will be necessary to lift the hour circle, &c., out of the bowl by means of the ends projecting at east and west. By placing the sector upright, the sights may also be used for taking magnetic bearings.

In conclusion, I beg to be allowed to remark that the object sought for in the construction of this instrument is the production of a simple tool capable of being readily understood and easily used by an ordinary mariner, without reference to any abstruse calculations, and which is as reliable and perfect in the practical results of its operation as are the methods and formulæ of the mathematical navigator.

## SOCIETY OF ARTS.

### CANTOR LECTURES.

"On the Aniline or Coal Tar Colours."

By W. H. Perkin, Esq., F.R.S.

Lecture II.—*Contd.*

(*Continued from page* 90).

*Coal Tar, Benzol, Nitrobenzol, Aniline, and Aniline Purple or Mauve.*

Commercial magenta consists of brilliant crystals, sometimes half-an-inch in length, having a beautiful golden green metallic appearances; these dissolve in warm water almost entirely, forming an intense purplish red solution. Dr. Hofmann has carefully studied the chemical nature of magenta, and has found it to consist of the salt of an organic base, which he has called rosaniline. This base may be obtained from the commercial product, by dissolving it in water and boiling it with an alkali, or alkaline earth, such as ammonia, potash, or lime; it is thus rendered nearly colourless, and after filtration rosaniline separates from the clear solution, on cooling, in colourless crystals. It is composed of carbon, hydrocarbon, and nitrogen when anhydrous, but generally contains an equivalent of water also. The anhydrous base has the formula—

$$C_{20}H_{19}N_3$$

This colourless base immediately becomes dark red upon combining with an acid, as I can show you by heating some acetic acid, when the colour is immediately developed. The magenta produced by heating commercial aniline with nitrate of mercury is the nitrate of rosaniline; that produced with arsenic acid is the arseniate, but in the process of purification this latter salt becomes converted into hydro-chlorate, which is the salt most generally found in the market. Other salts are also commercially manufactured, such as the oxalate and acetate, especially when a very pure product is required; these salts are generally prepared from pure rosaniline, by combining it with the required acid, and crystallising from water.

The acetate of rosaniline crystallises in magnificent octahedra, possessing the ordinary golden green metallic lustre to a very high degree; it is also the most soluble salt of rosaniline known. The affinity of rosaniline salts for animal fibres is very great; it does not, however, resist the action of light nearly to the same extent as the mauve. All the derivatives of rosaniline also possess a very great affinity for animal fibres, in most cases quite equal to that of magenta itself.

When speaking of aniline purple, I showed you that by reducing agents it became colourless, or nearly so, but that the original colour was developed when it was exposed to the oxygen of the air. Salts of rosaniline or magenta are also decolourised by reducing agents, but, unlike aniline purple, the colour is not restored by exposure to the air. Dr. Hofmann has found that in this case a new organic base is produced which he has called leucaniline. This substance differs only from rosaniline in containing an additional quantity of hydrogen. It may be reconverted into rosaniline by oxidising agents such as bichromate of potassium, &c.

There is another very peculiar reaction of rosaniline. This base, when brought in contact with hydrocyanic acid, instead of forming a coloured hydrocyanate of rosaniline, yields a perfectly colourless body, which is not a salt but a base. This remarkable fact was discovered by Dr. Hugo Müller, and he has called this new body hydro-cyanrosiline. We shall have occasion to refer again to this substance and leucaniline.

In the formation of magenta, a second product is obtained, commercially called phosphine. This substance was first introduced by Mr. E. Nicholson. Dr. Hofmann has investigated it, and found it also to contan an organic base, which he has called chrysaniline.

Phosphine or chrysaniline is not capable of being produced at will, and the quantity formed in the manufacture of magenta is variable. In shade it is of rather a yellow orange. This colouring matter differs from rosaniline, the base of magenta, in exactly the opposite direction to leucaniline, containing two atoms less of hydrogen. Leucaniline, rosaniline, and chrysaniline, are thus related:—

Leucaniline .......... $C_{20}H_{21}N_3$
Rosaniline .......... $C_{20}H_{19}N_3$
Chrysaniline .......... $C_{20}H_{17}N_3$

The principal use of phosphine is for the formation of a scarlet with magenta. It is not converted into magenta, nor decolourised with reducing agents or hydrocyanic acid, and therefore does not seem to be of the same class of colouring matters as rosaniline.

From the residues obtained in the manufacture of magenta three new colours have been obtained by Messrs. Girard and Delaire, but, I am sorry to say, my time will not allow me to enter the particulars of these products. I believe they have not been commercially introduced as yet.

Magenta is now more used as a source of other colours than as a dye. This has caused its manufacture to be conducted on a very extensive scale, and it is now looked upon by the manufacturer as a raw material much in the same way as aniline was regarded in the early days of aniline purple.

We will next consider some of the derivatives of magenta, and the first we will study is aniline blue or bleu de Lyon. If aniline be treated with a salt of rosaniline or magenta, a remarkable change takes place; at first the colour gradually becomes purple, but afterwards get quite blue, ammonia being evolved at the same time. This peculiar reaction was observed by MM. Girard and Delaire, who found that this change of colour was due to the formation of a new body, which they termed the bleu de Lyon; intermediate products were likewise obtained, to which we shall refer presently. MM. Girard and Delaire patented their process in January, 1861. This new aniline blue is one of the most important of the artificial colouring matters, and its manufacture has been very much improved upon since its discovery. There are several circumstances which materially influence the beauty of its tint, such as the quality of the aniline and the particular salt of rosaniline employed in its manufacture. It is found by experience that the aniline should be as pure and free from toluidine as possible, and that the salt of rosaniline should contain a feeble acid, such as the acetate, velerate, oleate, or benzoate; but why the latter is necessary chemists are unable to understand at present. Practically, the various salts of rosaniline required for the manufacture of the blue are not prepared separately, but are produced in the operation by double decomposition, which is simply a process of exchange; thus, if acetate of rosaniline is required, a mixture of hydrochlorate of rosaniline and acetate of sodium is employed; these re-act on each other, and change into acetate of rosaniline and chloride of sodium.

On the large scale, the process of making aniline blue is carried out in various ways, but many emyloy the apparatus shown in fig. 6. This appartus consists of an oil bath, *a*, set in a brick furnace; it has a cover, *b*, perforated with large holes; into these holes are placed small enamelled cast-iron pots, *c*, provided with a flange, on which they rest. These pots will hold from three to five gallons, and are fitted with lids held down with clamps; each lid is provided with a small stuffing-box, through which the rod of a stirrer, *d*, passes. In the lid are also two other perforations; one of these is fitted with a wooden plug, *e*, for the purpose of testing the progress of the operation; the other is connected with a bent, movable tube, *f*, united to a long central main, to collect any aniline vapour which passes over. This main is connected at one end with a worm, *g*. to condense the vapours. The oil bath by which these pots are heated is provided with a thermometer, so that the temperature may be properly regulated. In preparing the blue a mixture of magenta, acetate of sodium and aniline being employed in excess. When charged the oil bath is heated up to 190° C., and kept near that temperature. At first the red colour of the mixture changes slowly, but afterwards with rapidity. The progress of the operation is ascertained by removing the wooden plug, and withdrawing a small quantity of the product upon the end of an iron or glass rod, and it is considered complete when a good blue colour has been obtained; to ascertain this point with precision, considerable experience is necessary. The excess of aniline distils during this operation, and is condensed by the worm, and collected in a suitable receiver, so that it may be used again.

From the crude blue product thus obtained, which is a fluid of the consistency of treacle, all the different qualities of blues found in the market are prepared. The cheaper qualities are obtained by simply treating the crude product several times with hydrochloric acid. This removes all the free aniline, and most of the red and purple impurities. Another similar but more effective process is employed for the preparation of the better qualities, and consists in mixing the crude product with methylated spirits of wine, and pouring it into water acidulated with hydrochloric acid, and then thoroughly washing the colouring matter which it precipitates with water. But for the purest kinds of blue there are several processes employed; these are based upon the difficult solubility of some of its compounds in alcohol. In preparing these very pure qualities of blue, instead of starting with the crude product, one of the purified blues is taken.

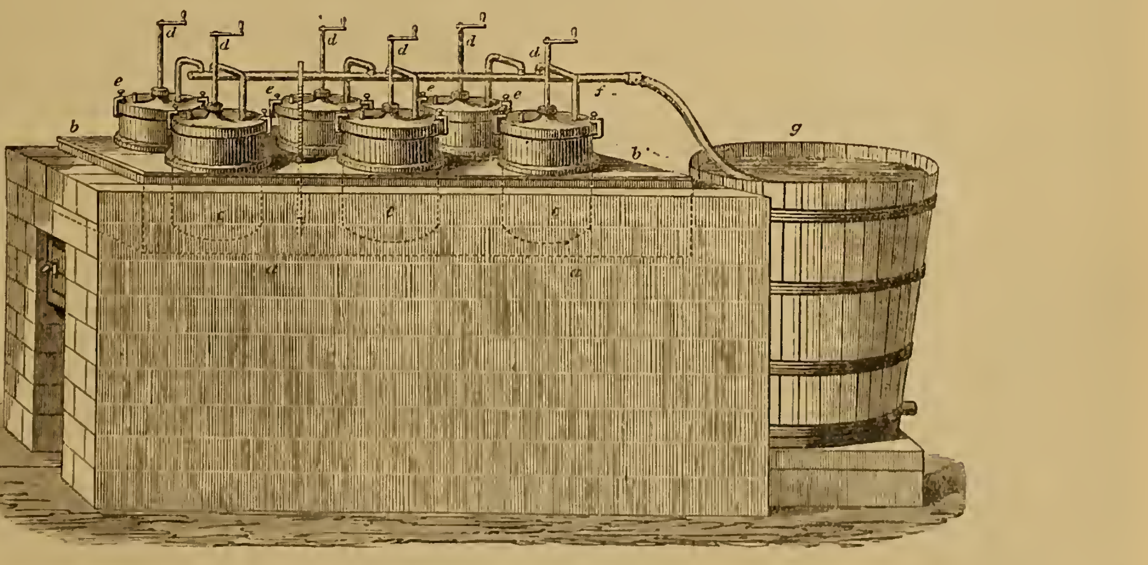
Aniline blue, or "bleu de Lyon," is supplied to consumers as a coarse powder having a coppery lustre, or in alcoholic solutions; it is nearly insoluble in water, and has to be dissolved in alcohol before it is added to the dye bath.

The nature of this blue has been determined by Dr. Hofmann. It is found to contain, like magenta, a colourless base, becoming blue only upon combining with acids. Dr. Hofmann has shown this base to contain—

$$C_{38}H_{31}N_3$$

and has called it "triphenylrosaniline." Like rosaniline, it becomes colourless

Fig. 6.



when treated with nascent hydrogen, forming a new base, giving colourless salts, as leucaniline. The composition is—

$$C_{38}H_{33}N_3$$

The insolubility of aniline blue in water has been found a great drawback to its use, because when employed for dyeing it is thrown out of solution in the dye bath, and then mechanically adheres to the goods, so that it afterwards rubs off.

Mr. Nicholson has, however, discovered a process for rendering this blue perfectly soluble in water. His process closely corresponds to that employed to render indigo permanently soluble. This, it will be remembered, is effected by subjecting indigo to the action of concentrated sulphuric acid, whereby a sulpho acid is produced.

Mr. Nicholson has found that aniline blue, when treated by a similar process, also forms a sulpho acid, perfectly soluble in water, and forming with alkalies nearly colourless solutions. These, however, when decomposed by acids, change back to the original blue.

This soluble blue is now much used for silk dyeing, but by dyers it is not thought to be so fast as the normal compound. By some modification of the process just described, Mr. Nicholson has obtained another soluble blue, commercially known as "Nicholson's blue." This is now very extensively employed in Great Britain for wool dyeing, but its application does not appear to be well understood in France and Germany, so that its use there is not so great as in our own country.

If a salt of rosaniline and aniline be heated together, and the process stopped before aniline, blue is produced, the resulting product when treated with dilute acid gives a colouring matter, which has been called "violet imperial." This was at first supposed to consist of a mixture of blue and magenta, but recent research has shown it to consist of intermediate products. Very large quantities of this colouring matter have been used, but its consumption is now rapidly falling off, owing to the introduction of new violets, about to be described. A few months after the discovery of aniline blue, another colouring matter, called the "bleu de Paris," was obtained by M. M. Persoz De Luynes and Salvetat. These chemists found that when aniline was heated with tetrachloride of tin for thirty hours to 180°C. in a sealed tube, neither a red nor a violet, but a very pure blue was produced. This colouring matter is generally described as being identical, or probably identical, with the bleu de Lyon. These blues are, however, widely different in their chemical nature, as the bleu de Paris is easily soluble in water, and crystallizes freely in needles of a blue colour, with a coppery reflection. It consists of the hydrochlorate of an organic base, which is precipitated from its solution by alkalies as a purplish blue powder; it dyes silk readily, and retains its blue colour by artificial light. It is remarkable that the discoverers of the bleu de Paris do not seem to have observed its difference from the bleu de Lyon.

I have prepared some of this product with a view to its examination, but hitherto have been prevented from determining its composition. I hope to do so soon.

The bleu de Paris is, unfortunately, difficult to prepare in large quantities, and has never been introduced commercially.

The recognition of the nature of the bleu de Lyon, by Dr. Hofmann, led him to study the action of a class of substances upon rosaniline, known to chemists as the iodides of the organic radicals; this investigation resulted in the discovery of the brilliant colours known as the Hofmann violets, and of which so many shades can be obtained, from a very red purple to a nearly pure blue.

The substances generally used for the preparation of the Hofmann violets from rosaniline are the iodides of methyl and ethyl; the iodide of methyl differs from that of ethyl in a practical point of view, in being rather quicker in its action; it is also more volatile. Both these substances contain a remarkable element called iodine. This body is found in sea-water and sea-weed; its aspect is very similar to that of a metal; one of its characteristic properties is that when heated it volatilizes and produces a beautiful purple coloured vapour, and here we find how dangerous a little knowledge is when relied upon. When the iodide of ethyl, which, as I have told you, contains iodine, was introduced for the preparation of the Hofmann violets, it was stated in some of our periodicals or daily papers, I do not remember which, that chemists had at last succeeded in fixing the colour of iodine, whereas, the iodine has nothing whatever to do with the colours produced with the iodides of ethyl and methyl, but is simply an instrument in bringing about the change which takes place in their formation; moreover, these colours can be equally produced without using iodine at all. It is unfortunate that the popular reports upon scientific matters are generally so utterly untrustworthy. One of the most remarkable reactions of iodine is the blue violet colour it gives with a solution of starch; this is used as a test for its presence when in the free condition, and is remarkably delicate; it is no use as a colour, as it is instantly decomposed when heated. To prepare iodide of ethyl, ordinary alcohol is treated with iodine and phosphorus; the operation has to be conducted with care, as iodine reacts upon phosphorus with great energy; usually the alcohol and phosphorus are placed in a retort, and the iodine added very carefully, and in small quantities at the time. The mixture is then distilled. and the distillate mixed with water, which causes the iodide of ethyl to separate as a colourless heavy oil. Iodide of ethyl is very volatile, boiling at 70°C.; it has an ethereal odour, and when pure is colourless and transparent; it contains no less than 81 per cent. of iodine. Iodide of methyl is prepared in exactly the same manner as that of ethyl, substituting wood naphtha, or methylic alcohol, for ordinary alcohol; it contains a still larger quantity of iodine than the iodide of ethyl, viz., 89 per cent.

For the preparation of these substances on the large scale special apparatus has been devised, and sometimes amorphous or red phosphorous is substituted for the ordinary kind; but I shall not have time to enter more fully into this subject. To produce the violets, Dr. Hofmann heats pure rosaniline with iodide of ethyl, or methyl and methylated spirits of wine, in a cast-iron digester, closed air-tight, with a lid fastened down with screws. A process very similar to this is sometimes employed, and consists in using a salt rosaniline. caustic alkali, iodide of ethyl and alcohol. But in Germany the ordinary hydrochlorate of rosaniline is employed with alcohol, or wood spirit and iodide of ethyl, and is found to work very successfully. By employing the rosaniline itself a lower temperature is required for the formation of violet, than when using its salts; in fact, I have found that a mixture of iodide of ethyl and rosaniline re-act even at the ordinary temperature if left in contact for a few days, and produce a red shade of violet.

On the large scale Hofmann's violet is generally prepared in deep cast-iron vessels, surrounded with a steam jacket, and provided with a lid having a perforation, closed with a screw plug. This lid can be firmly fastened down with screws, the joint being made with a vulcanised indiarubber washer. This apparatus is charged with a mixture of hydrochlorate of rosaniline dissolved in alcohol or wood spirit, and iodide of ethyl or methyl, in proportion according to the shade required. After the apparatus is closed the steam is allowed to enter the steam jacket, and the heating continued for five or six hours; the plug is then removed from the lid of the apparatus, and the alcohol or unused iodide of ethyl distilled off. The resulting product is dissolved in water, filtered, and precipitated with chloride of sodium, but sometimes it is first treated with caustic alkali, to remove all the iodine, so that it may be recovered. Thus obtained, the colouring matter is of a golden lustre if of a blue shade, and of a greenish if of a red shade.

Like all the other colours we have considered, the Hofmann violets are nearly white organic bases, their composition differing according to the shade of colour, thus:—

A red shade is composed of.................................................$C_{22}H_{23}N_3$
A red violet shade, of .......................................................$C_{24}H_{27}N_3$
A very blue shade .............................................................$C_{26}H_{31}N_3$

The colours of the Hofmann violets are remarkable for their brilliancy, but, unfortunately, they do not resist the action of light so well as might be desired; it is remarkable, however, that the regard for fastness seems to have given way to the desire for brilliancy.

In the early days of coal-tar colours fastness was so much talked about, that when magenta was first introduced it was thought by some that it would not be largely used—how different has it proved to be. Although not very fast upon cotton, the Hofmann violets are sufficiently so for woollen and silk goods, as colours always resist the light better when applied to animal fibres.

In the formation of Hofmann violets we see that rosaniline, when treated with iodide of ethyl, becomes blue, the red being converted into violet; but with mauveine, the base of the mauve, exactly the reverse takes place, the mauveine being converted into a much redder shade with iodide of ethyl. The colouring matter produced from mauveine and iodide of ethyl is commercially known as "dahlia;" the colour is intermediate in shade between aniline purple and magenta. This colouring matter possesses the same character for fastness as the mauve, and also gives the same reactions with acids; unfortunately it is rather expensive, and has therefore not been very extensively used.

Lastly, there has been a process proposed for the production of colouring-matters similar to the Hofmann violets, by first converting the aniline into ethyl-aniline, a base previously discovered by Dr. Hofmann. It is found that by substituting this base for aniline, in some of the processes which have been employed for the manufacture of magenta, the ethyl-aniline yields purple or violet colouring-matters.

This process has been patented by M. M. Poirier and Chappat, but the reaction appears to have been first observed by M. E. Kopp. From the great similarity of these colouring matters to the Hofmann violets, I need not enter into any lengthened description of their properties.

Sea-water contains, besides iodine, another remarkable element called bromine; it is a liquid giving off very irritating orange-coloured vapours. This remarkable body yields, with many hydro-carbons, a great variety of compounds. With ordinary turpentine, it acts with great violence; but if the action be moderated by the presence of a large quantity of water, a thick viscid oil is obtained. This body was examined by Mr. C. Greville Williams, who found it possess the formula—

$$C_{10}H_{15}Br._3$$

I have found that this substance, when heated with a solution of magenta in methylated spirits, produces a purple colouring matter of great beauty, commonly known as the Britannia violet: it is very extensively employed for dyeing and printing, and can be produced of any shade, from purple to a blue violet.

The Britannia violet possesses the golden green lustre so common to all the aniline colours. It is easily fusible, amorphous, and very soluble in water.

In my last lecture I showed you the great intensity of the mauve dye. I will now make a few experiments, to illustrate the great intensity of some of the colouring matters we have been considering this evening.

I have here some screens of white paper, on which I have dusted a very small quantity of the solid colouring matters,—so small a quantity that I dare say you can scarcely discover its presence. If I now project spirits of wine upon these screens, so as to dissolve the colours, you will see their remarkable intensity.

Let us now consider for a moment the great rapidity with which the discovery of new coal-tar colours followed that of the mauve or aniline purple

Aniline purple was discovered in 1856; three years afterwards, in 1859, the magenta was introduced. In 1861 we had the aniline blue; in 1863 the Hofmann violet; and in 1865 the Britannia violet. Thus we see that all these colours have not only been discovered, but introduced commercially, in a period of less than ten years.

We have now reviewed the principal coal-tar colours, but there still remain some important ones for our consideration next lecture; and although some of these are not at present largely used, yet it is to them, perhaps, that we may look for the future development of this branch of industry.

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## INSTITUTION OF CIVIL ENGINEERS.

### EXPERIMENTS ON THE STANDARDS OF COMPARISON EMPLOYED FOR TESTING THE ILLUMINATING POWER OF COAL GAS.

By Mr. T. N. Kirkham, M. Inst. C.E.

It was observed that the standards of comparison at present in use were known to be wanting in that uniformity of result necessary for determining with accuracy the difference in the intensities of two lights. But as the amount of the variation had never been clearly defined, the Author had instituted a series of experiments for the purpose of ascertaining the extent of these differences.

The instruments employed for testing the illuminating qualities of two flames were founded on the law of optics, that light diverging form a luminous centre dimished in intensity in the ratio of the square of the distance. This principle had been taken advantage of by Count Rumford in the instrument known as the 'Jet Photometer,' which was described; as was also another method, suggested by Professor Bunsen, which was dependent for its action upon the combination of reflected and transmitted light.

In France, the instrument employed was M. Foucault's modification of that proposed by Count Rumford, as arranged by MM. Dumas and Regnault; while the standard of comparison was the amount of light emitted from colza oil, specially prepared and verified, burning in a Carcel lamp, of certain fixed proportions, at the rate of 42 grammes (648 grains) per hour; and it was required that the light produced by from 25 to 27½ litres (·8625 to ·9707 of a cubic foot) of gas, consumed in a Bengel burner of known dimensions, should be of equal power. The mode of conducting an experiment with this instrument was then detailed; and it was explained that during the progress of the experiment, the quantity of gas was regulated, so that the two lights should be maintained of equal intensity. In this way it was possible to compare the consumption of oil with that of the gas, and if the lamp had burned at the specified rate of 42 grammes (648 grains) per hour, the experiment should have been completed in 14 minutes 17 seconds.

In England, the instrument in use was constructed on the Bunsen principle, and the standard of comparison, as defined by Act of Parliament, was a sperm candle, burning at the rate of 120 grains per hour. The gas being consumed at the rate of 5 cubic feet per hour, through an Argand burner having 15 holes, and with a chimney 7in. high, must be equal, in intensity of light, to 12 such candles.

The instrument by means of which the experiments were made by the Author was also constructed on the Bunsen principle, combining all the most approved modifications. It consisted of four photometers, radiating from a common centre in the form of a Cross, and each accurately scaled, adjusted, and fitted with every appliance to ensure uniformity and precision.

The first series of experiments was undertaken for the purpose, if possible, of arriving at the amount of variation in the illuminating power of candles obtained from the principal manufacturers. Gas was adopted as a standard of comparison; and to insure uniformity in its illuminating power, a sufficient quantity for carrying out the experiments on each occasion was put into a gas holder in the laboratory, the temperature in the latter being always maintained at 62° Fahrenheit. In this series, each of the four photometers was supplied with candles of a particular make, to the use of which it was restricted throughout the day, every successive experiment being made with a separate specimen. All the candles were cut in half and burned from the centre. It was observed that, although the standard candle was fixed by Act of Parliament, as a sperm candle, of six to the pound, burning uniformly at the rate of 120 grains to the hour, yet no such candle was to be obtained; for from various quantities of sperm candles six to the pound, procured from several manufacturers, the average rate of consumption was 135 grains. This fact had been previously demonstrated by the extended series of experiments carried out by Professors Graham, Leeson, Brande and Cooper in 1852, The Parliamentary rate, being abnormal, was so rarely met with, that all operators had been compelled to make corrections for these variations, and had unanimously adopted the ordinary rule of simple proportion for the purpose. It was proposed, therefore, in the analysis of the diagrams exhibiting the results of the experiments, that the candles burning at the rate of 135 grains should be designated 'normal standard candles,' to distinguish them from the Parliamentary standard of 120 grains.

Commencing with experiments Nos. 56 and 58; in No. 56, with a consumption of 119 grains, the illuminating power of the standard gas was represented as 15·3 candles; whilst in No. 58, with a consumption of 121·2 grains, it was 14·5 candles. The difference between these two experiments, made with candles which happened to be nearly within the Parliamentary standard, was ·8 of a candle. In experiment No. 51, burning the normal standard quantity of 135 grains, the same gas was represented as being 15·48 candles; and in No. 61, consuming 134·4 grains, or ·6 of a grain less, it was 16·28 candles, the difference being in this case also ·8 of a candle. In experiment No. 60, with a consumption of 134·7 grains, or only ·3 of a grain more, the gas was shown to be 18·18 candles, a difference of 2·70 candles. In experiment No. 51, with a consumption of 129 grains of sperm, the gas had an illuminating power of 12·6 candles. In experiment No. 52, with a consumption of 145·2 grains, the gas appeared to be 12·6 candles. Experiment No. 52, with a consumption of 157·2 grains, gave the gas as 12·54 candles. The last three experiments were examples of candles consuming different quantities of sperm, yet giving practically the same amount of light; the correction of which to the Parliamentary standard of 120 grains created error. Experiments Nos. 57 and 54, each with the same consumption of 130·2 grains, showed the difference in the illuminating power of the gas to be 2·42 candles; the former representing it as 13·02, and the latter as 15·44 candles. These were examples of candles burning the same quantity of sperm, yet giving a different amount of light. The greatest difference in the illuminating power of the 'standard gas,' as shown throughout the forty-four experiments made upon this day, was 4·60 candles; being between experiment No. 51, with a consumption of 129 grains, giving an illuminating power of 13·58 candles, and experiment No. 60, consuming 134·7 grains, representing the gas to be 18·18 candles.

An examination of the various diagrams would demonstrate, that the differences in the candles might be classed under five heads; viz.—First. Differences in the illuminating power of Parliamentary standard candles, burning at the rate of 120 grains per hour. Secondly. Differences in the illuminating power of normal standard candles, burning at the rate of 135 grains per hour. Thirdly. Candles with different rates of consumption, giving the same amount of light. Fourthly. Candles with the same rates of consumption, giving a different amount of light. And fifthly. Greatest differences of illuminating power, in the whole number of experiments, when corrected to the Parliamentary standard.

From the tabulated results of three other sets of experiments, it appeared that, in the first, when the consumption of sperm varied from 109·2 to 134·4 grains, the greatest difference in the illuminating power of the gas, corrected to the Parliamentary standard, was 4·59 candles; in the second, when the consumption ranged from 120·9 to 130·8 grains, the difference in the illuminating power was 3.06 candles; while in the third, with a consumption of from 120 to 142·5 grains, the difference was 4·21 candles.

The second, third, and fourth series of experiments were made with candles obtained from one manufacturer only. As an example of the results arrived at by the second series, it was stated that with a consumption of sperm varying from 129.6 to 130.2 grains, the greatest difference in the illuminating power was 2.26 candles.

The third series of experiments was made for the purpose of ascertaining whether the French standard of comparison, when used at a photometer on the Bunsen principle, was more reliable than the candle. It was thus found, that when the lamps were allowed to burn without any regular system of trimming, the variations were about as great as those of the candles; but when the lamp was trimmed before the commencement of each experiment, the variation was about the same as with the best candles. It was probable that the results would have been better, if the time allowed for taking the observations had been fifteen minutes instead of ten minutes; for the lamp when filled weighed 10lbs., and the balance employed would not turn to less than a grain. Subsequent experiments corroborated this supposition. Of this series the examples selected showed, in one case that the greatest difference in the illuminating power of the gas was 1·69 candle, with a consumption of sperm ranging between 136·5 and and 124·5 grains. In another case the greatest difference in illuminating power, corrected to the standard consumption of 108 grains of oil in ten minutes, shown in the whole number of experiments, was 2·3 candles, when the time required for the consumption of 108 grains of oil by the lamps was respectively 8 minutes 39 seconds and 10 minutes 3½ seconds.

For several years past, the Author had in operation one of Mr. Lewe's jet photometers, for the purpose of indicating the illuminating power of the gas as it was being manufactured. As its apparent accuracy seemed to promise a more reliable means of determining the illuminating power of gas, it was decided to carry out a fourth series of experiments, with a view to discover the relation between the indications of this instrument, and those of the French and English standards. At the 'Cross' photometer, three consecutive experiments were made upon the quality of the gas, compared with four candles burning at the same time. The results of these twelve experiments were then averaged, and accepted as the illuminating power of the gas in each case. Another operator was at the same time engaged at the Dumas and Regnault photometer, and the average of these experiments was also taken as representing the illuminating power of the gas. Two of Mr. Lowe's jet photometers, fitted precisely alike, were in operation throughout these experiments; the orifice in each jet being of the same size, so that at any given pressure the height of the flame from each would be the same. The pressure at the point of ignition was regulated so as to give a flame exactly 7in. in height, and that pressure was duly recorded. The height of the flame at a pressure of ·6 of an inch was also observed, as well as the time required for the issue of ·1 of a cubic foot of gas under each of these pressures.

A diagram was prepared, showing the results of simultaneous experiments for ascertaining the illuminating power of gases of different qualities, by two different systems, as at present existing, and by the proposed plan of testing by the jet. On this diagram a diagonal line had been drawn, which illustrated the theory of ascertaining the illuminating power of gas by means of the jet photometer, worked on the 'Retrograde system,' which might be thus stated;—Maintaining a 7in. flame from an orifice of certain fixed dimensions, the illuminating power of the gas was in direct proportion, inversely, as the pressures.

This diagonal line being considered as the 'standard 7in. flame,' according to the theory just advanced, it was observed that the average results of twelve experiments very nearly coincided with the theory; and at pressures of ·45, ·51, ·63, ·64 and ·68 of an inch this was especially the case. The highest and the lowest candle experiments were completely cut by the line, and the lamp experiments also tended generally to prove the theory.

Another diagram, representing the Duration Test corresponding with the retrograde scale, showed the time required for the issue of ·1 of a cubic foot of gas, of a certain illuminating power, maintaining a 7in. flame from the jet photometer. The use of the Duration Test was to check the working of the jet photometer, and to afford a means of discovering any irregularities that might occur in the apparatus. As an example of its use, it was seen by the retrograde scale that gas having an illuminating power of 14 candles gave a 7in. flame at a pressure of ·63 of an inch; and upon referring to the Duration Test it would be found, that ·1 of a cubic foot of gas of that illuminating power ought to maintain that flame for three minutes. Should there be any considerable deviation, it was an evidence of some derangement in the apparatus.

From these experiments the Author believed it was evident, that a more reliable method than that at present in use, for determining the correct illuminating power of the gas supplied to the public, was urgently needed; and he thought the following system would be found to give results approaching as nearly as practicable to a truthful estimate: Let the illuminating power of the gas be determined by the aid of the present recognized photometer, fitted with a Carcel lamp, burning oil of the same quality, and verified in the same manner, as that adopted by the Municipality of Paris as a standard; and let a sufficient number of experiments be made so as to cover the errors that were known to exist, and the average of these be compared with the illuminating power, as shown by the jet photometer and the Duration Test, and then the 'mean of comparison' might be taken as the illuminating power of the gas.

At the meeting on Tuesday, the 6th ult., Mr. Charles Hutton Gregory President, in the Chair, ten candidates were balloted for, and declared to be duly elected, including one Member, viz.:—Mr. William Adams, Locomotive Superintendent of the North London Railway, Bow; and nine Associates, viz.: —Mr. William Francis Badgley, Assistant Surveyor 1st Grade, Topographical Survey of India; Mr. Arthur Carpmael, Southampton Buildings; Mr. William Hackney, B. Sc., Westminster; Mr. Francis Henry Hambleton, Baltimore, U.S; Mr. Thomas Crump Hambling, Westminster; Mr. Charles Benjamin Knorpp, Acting Executive Engineer in the service of the Madras Irrigation and Canal Company: Mr. William Francis Lawrence, King's Lynn; Lieutenant Richard Arthur Sargeaunt, R.E.; and Mr. George Frederic Verdon, C.B., Agent General for Victoria, Australia.

It was also announced that the Council, acting under the provisions of Section IV. of the Bye-Laws, had recently admitted as Students of the Institution, Messrs. Henry Carter, William Alfred Dawson, and John Henry Richard King.

## LONDON ASSOCIATION OF FOREMEN ENGINEERS.

The members of this institution met on Saturday the 3rd ult., in their new hall at the City Terminus Hotel, and the assemblage was much more numerous than at any previous monthly meeting. The chair and vice-chair were filled by Mr. Newton, of the Mint, and Mr. Keyte, respectively. The first business consisted in the election of Mr. James Douglass, Chief Engineer to the Trinity Board, and Mr. W. Munro, of Lambeth, as honorary members, and of Messrs. T. Hughes, J. F. Wolff, J. E. Reed, H. Noble, R. Wood, and J. Bates, as ordinary members; Messrs. W. Fothergill, and W. Price, were also put in nomination for membership in the ordinary class.

Mr. Newton then proceeded to deliver an address. He commenced by congratulating his fellow members upon the advancement—steady, and apparently certain—which the Association was making, and upon their having obtained a suite of apartments in all ways so well adapted for their monthly gatherings. It was in 1855, when the society was in its infancy, and when it was regarded with a considerable amount of jealousy and distrust by employers, that he (Mr. Newton) had joined its ranks, and he was thankful he had lived to witness its development to its present state, and the disappearance of every vestige of antagonism to it on the part of the master engineers of the kingdom. To the scientific press of London much of the success of the Association was due. Through its medium the transactions of the society was made known to the engineering community at large, and its internal mechanism and its springs of action explained. The inner life of the institution, and its peculiar blending of scientific investigation with benevolent design, had thus been revealed, and its adaptability for technical and practical purposes demonstrated, until, at last, the principal employers of London were among the firmest friends of the Association. This, Mr. Newton said, was matter for extreme congratulation, but there was still work to be done. It seemed impossible for individuals trained, as foremen were, in the workshop, not to be cognizant of the value as well as the dignity of labour, and labour was still essential to the prosperity of that society. Their barque had tided over many shoals, and escaped many quicksands, but the sea of public life abounded in hidden as well as patent dangers, and it was necessary always to keep a good look-out, and that the crew should, one and all, be prepared to do their duty. Hitherto, some of the ship's company had merely lounged upon the deck, and contributed little towards bringing the vessel into harbour. He hoped that the idle members of the past would become the active workers of the future, and then, humanly speaking, all must go well with that institution.

Mr. Newton adverted to the gratifying fact that Dr. Percy and Professor Tyndall had promised papers on future occasions, and that thus there would be a welding, as it were, of scientific deduction and practical knowledge in their proceedings.

By co-operation of this kind all would be benefited intellectually, and the information gained at the meetings would be utilized in the factory, so as to be made advantageous to employers. In conclusion, the chairman appealed to honorary members to come forward and assist the society by reading papers, and by joining in discussions. They might enter that hall without any sacrifice of dignity, and their presence would be hailed with the greatest satisfaction.

The foregoing is but a brief *resume* of the chairman's address, which was listened to throughout with great attention, and applauded at its close. Mr. Robt. B. Vinicombe, of the Royal Arsenal, Woolwich, followed with a paper on "Gunpowder Machinery," This was of a thoroughly practical nature, and the whole of the processes connected with the production of the death-dealing compound were admirably explained by the author. The paper was copiously illustrated with diagrams, and was altogether calculated to enrich the transactions of the institution. The proceedings of Saturday were protracted to a late hour; but Messrs. Keyte, Irvine, Humes, and others, took part in the brief discussion which followed Mr. Vinicombe's elaborate treatise, and votes of thanks to that gentleman and Mr. Newton concluded the meeting.

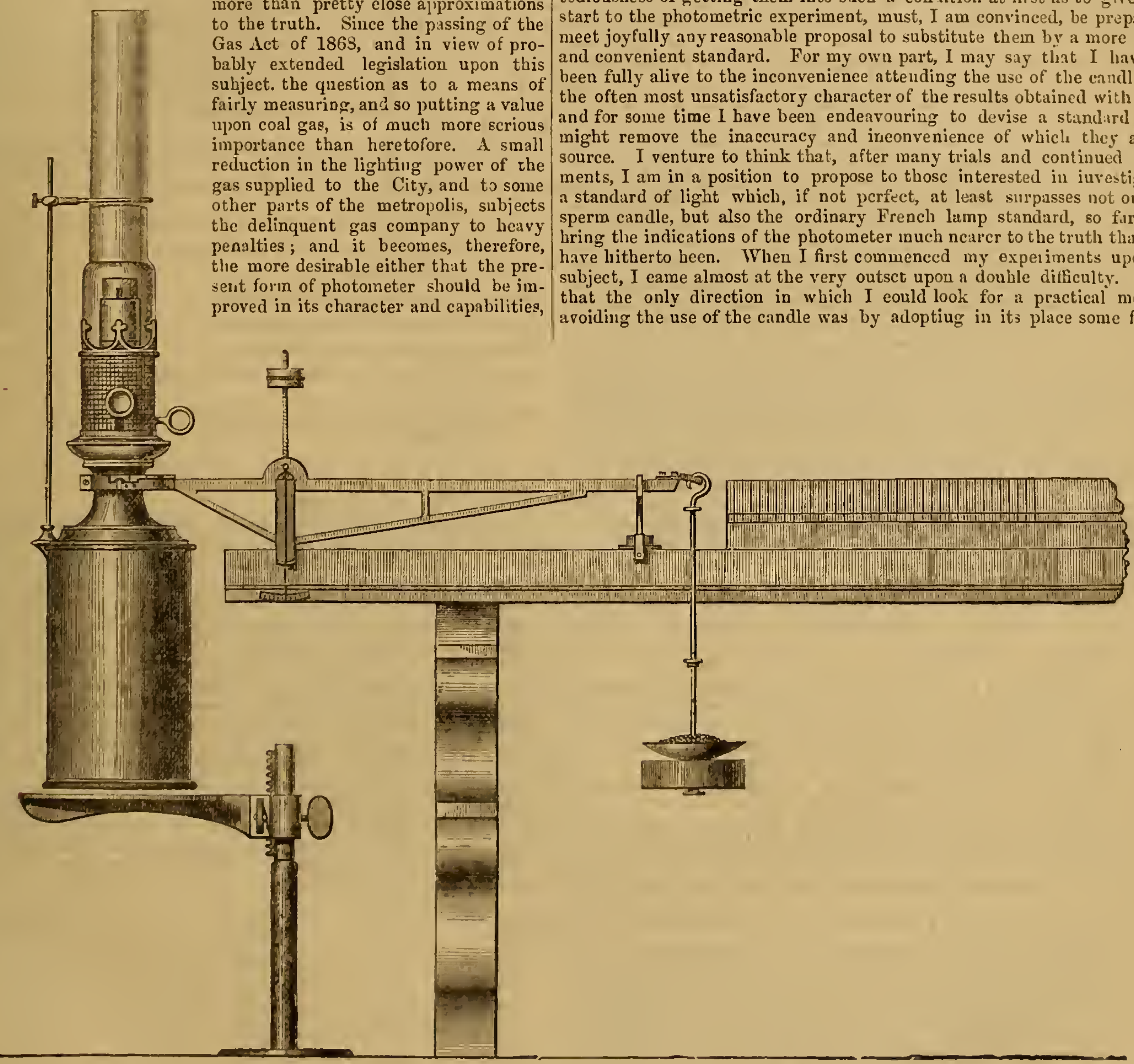
## ROYAL GEOGRAPHICAL SOCIETY.

At the evening meeting of this society on the 5th ult., Sir Roderick Murchison, president, in the chair, a paper by Captain T. G. Montgomerie, of the Indian Survey, was read on the explorations of two Pundits travelling under his orders between the northern frontier of India and Thok Jalung, in Thibet. The meeting was attended by Lord Lawrence, Sir Robert Montgomery, Sir H. Rawlinson, and other distinguished men connected with India. The Pundits, well provided with surveying instruments concealed in ingeniously contrived compartments of their travelling chest, entered North-Western Thibet by the Mana Pass (18,570ft.) on the 28th of July, 1867; they thence proceeded by Totling to Gartokh, crossing the Sutlej by a remarkable iron suspension-bridge of 76ft. span. The watershed between the Upper Sutlej and the Indus was crossed on the 9th of August by the Bogola Pass 19,220ft.; and, avoiding the town of Gartokh, they crossed another lofty range by a pass 19,500ft. high on their way to the gold mines, which they were anxious to reach further to the east. At the principal gold diggings they were finally stopped by the Thibetan Governor, who suspected they were not traders, as they professed themselves to be; and after a short stay they were compelled to retrace their steps. On their return they explored a river north-east of Gartokh, which was previously quite unknown to geographers, and which proved to be the main stream of the Upper Indus. One of the Pundits ascended it to within a few marches of its source, east of the Kailas Peak; another descended it to beyond its junction with the Gartokh River. A new range of lofty mountains, called Aling-Gangri, was also discovered; they lie to the north of the Upper Indus, and are estimated to have a mean altitude of 24,000ft. The country travelled over was a lofty barren plateau nowhere lower than 13,000ft. above the sea level; nothing but coarse grass grows on the elevations, but it is sufficient to support great herds of wild animals; very little of the ground was cultivated, and that little along the banks of some of the rivers at an elevation of 13,000ft. to 15,000ft. The climate at the mines is extremely cold, the elevation being 16,330ft.; the miners live in tents, pitched in pits dug some 7ft. or 8ft. below the surface. During this remarkable and successful exploration, 850 miles of route were surveyed, and the altitudes of 80 positions ascertained. The paper was prefaced by a letter from Captain Montgomerie to Sir Roderick Murchison, in which he stated that the Pundit in charge of the expedition was the same who performed the remarkable journey to Lhasa and the sources of the Brahmaputra, for which the Geographical Society had awarded him a gold watch—a testimonial which the Captain would present to him on his return to Dehra Doon. A third Pundit had accompanied him on the present journey, and was likely to do good work. In the discussion which followed Sir H. Rawlinson said great merit attached to Captain Montgomerie for devising and carrying out this method of exploring the unknown countries beyond the British frontier which the jealousy of the inhabitants rendered impenetrable to Europeans. He believed the goldfields visited by the Pundits, and stated by them to extend far to the north-west, reached as far as Eastern Turkestan, for the city of Ilchi had been the seat of the gold traffic for a long period. In fact, these goldfields were doubtless the same as those mentioned by Herodotus as lying to the north of Cashmere, and worked by Ants. The application of the name of an animal to the miners was in accordance with a common practice in ancient times, when when many tribes bore the nickname of some species of animal: the burrowing habits of the Thibetan miners would probably suggest this name. Two letters were also read on the subject of Eastern Turkestan, and the prospect of trade, especially in tea, between British India and Yarkand; one of them was from Mr. T. Douglas Forsyth, and the other from Mr. R. Shaw. The latter gentleman had undertaken to convey a quantity of tea grown in the Kangra Valley to the Koosbegie of Independent Turkestan, and had succeeded in entering that country by way of the Changchenmo Valley and the Karakash River, and by Shadula and Sanju. The Koosbegie had acceded to his request to be permitted to visit Yarkand, and when last heard of he expected soon to reach that city. Sir Robert Montgomery explained to the meeting the project once entertained by the Indian Government of constructing a road direct from Simla eastward to Thibet, to join the old Royal road of that country, and thus open trade communication direct between India and Western China. The following new members were elected;—F. G Chinnock, F. H. Leaf, Roger Leigh, E. B. March, E. M. Underdown, C. M. T. Western, Rev. T. G. Wilson, B.A.

## NEW PHOTOMETER STANDARD LIGHT AND BALANCE.*

By Thomas William Keates, Esq., F.R.C.S., &c., Consulting Chemist to the City of London Gas Company.

Photometry is a subject which has risen into practical importance entirely within a few years, and which, from being a matter of scientific interest only in the hands of the chemist and physicist, has become the sole means of fixing the value, between seller and buyer, of one of the most necessary of the commodities of the time—that is, common illuminative gas. Photometry is, however, unsatisfactory as a measuring process. We have to encounter, *in limine*, the difficulty that we are bound to measure by an instrument which does not supply us with any exact standard of measurement; the consequence is that the valuations made by the photometer at the present time cannot be regarded as more than pretty close approximations to the truth. Since the passing of the Gas Act of 1868, and in view of probably extended legislation upon this subject. the question as to a means of fairly measuring, and so putting a value upon coal gas, is of much more serious importance than heretofore. A small reduction in the lighting power of the gas supplied to the City, and to some other parts of the metropolis, subjects the delinquent gas company to heavy penalties; and it becomes, therefore, the more desirable either that the present form of photometer should be improved in its character and capabilities, or that some more exact and reliable form of light-measurer should be devised. At present it seems unlikely that any really new form of photometer will come into use; it is, therefore, from some alteration in the arrangements of that now employed—known as Bunsen's photometer—that the practical gas analyst and examiner will have to look for relief from his difficulties. For some time after the introduction of this photometer it was the practice to use a single sperm candle, of a defined weight, as the standard of light, and the light of the gas measured by this standard was computed at so many candles power; after a time two sperm candles were used together—a great improvement, inasmuch as the irregularities of one candle counteracting in some degree those of the other, the light was made more regular than before, and the light of the standard being also doubled, the readings of the photometer were rendered clearer and more distinct.



Those who have been occupied with the use of the photometer have mostly found long ago that the sperm candle is a most defective standard of light measurement. The best candles burn more or less irregularly, *quoad* the particular candle; and, compared one with another, the candles differ so much in burning, although apparently alike in all particulars calculated to ensure regularity in that respect, that there has come to be a general feeling among photometrists that a new light standard is absolutely essential to the successful practice of photometry as a real means of establishing the value of illuminative gas. Every one who has experienced the uncertainty of the burning of the candles, and the difficulty and tediousness of getting them into such a condition at first as to give a fair start to the photometric experiment, must, I am convinced, be prepared to meet joyfully any reasonable proposal to substitute them by a more certain and convenient standard. For my own part, I may say that I have long been fully alive to the inconvenience attending the use of the candles, and the often most unsatisfactory character of the results obtained with them; and for some time I have been endeavouring to devise a standard which might remove the inaccuracy and inconvenience of which they are the source. I venture to think that, after many trials and continued experiments, I am in a position to propose to those interested in investigation, a standard of light which, if not perfect, at least surpasses not only the sperm candle, but also the ordinary French lamp standard, so far as to bring the indications of the photometer much nearer to the truth than they have hitherto been. When I first commenced my experiments upon this subject, I came almost at the very outset upon a double difficulty. I saw that the only direction in which I could look for a practical means of avoiding the use of the candle was by adopting in its place some form of oil-lamp. But in my earliest trials I found that I could not rely upon any lamp that I could obtain, and this for two reasons, operating singly or conjointly—first, the mechanical structure of the lamp was not suited to produce a uniform action in its parts; and, secondly, the fuel was of such a nature that there was no certainty that different specimens of the same kind of fuel would produce exactly similar effects in burning. In seeking for a lamp suitable to the use of the photometer, two desiderata suggest themselves at the very outset. The first of these is a regular supply of oil to the wick, at a given height and under unchanging pressure; the second, the use of a fuel unvarying in its composition and character, so that different specimens shall possess so nearly the same light-giving power that their effect, when burned under like conditions in the lamp, may be regarded as constant. I could find no lamp in which these requirements were satisfied when I began my investigations. It would be useless to enter into an account of my various failures with lamps of two or three different kinds; shortly, I may say that I commenced by endeavouring to modify the fountain lamp so that the supply of oil to the wick might be uniform; failing these, I turned to the ordinary moderator, with the same result; and that, finally, I have succeeded in obtaining a lamp which, burning sperm oil, appears to fulfil the objects in view in a degree which I had scarcely hoped to arrive at. In the course of a long professional connection with one of the largest of the oil-refining houses, I had acquired an intimate knowledge of the character of the burning oils, and of the peculiar circumstances attendant upon their preparation for the market. This knowledge enabled me to perceive at once that the number of oils from among which fuel for a standard light could be selected was very limited; and further reflection and experiment lead me to the conviction that there is, indeed, but one kind of oil fit for this purpose. Before, however, deciding upon the fuel to be burned, I had before me the problem of making the lamp capable of burning it. As I have already stated, I began my experiments upon the fountain lamp, which I soon gave up, and then began some trials with the common moderator. I found, however, two defects in this lamp, both of which were capable of destroying uniformity of its action; these were the moveableness of the chimney—that is, the capability of the chimney to be raised or lowered so as to increase or diminish the sharpness of the current of air thrown in upon the flame, whereby the oxidation of the burning material could be increased or lessened; and the way in which the oil was supplied to the wick by the action of the spring and piston throwing it over the upper edge of the metal wick-holder—governing, indeed, by the height of the overflow of the oil, the distance to which the flame could descend into the wick. Both these points in the construction of the lamp I looked upon as destructive to its uniform action. In the case of the chimney, if it were placed at different heights at different times, the amount of oxidation of the fuel would vary, and the height, colour, and intensity of the flame would also become inconstant; and in that of the oil supply, the height of the oil flowing over the edge of the burner would affect the height of the flame, and, I think, also its colour. The quantity of oil made to overflow, of course, depends upon the action of the spring which forces down the piston in the body of the lamp, and this action, being in proportion to the tension of the spring, is greatest immediately after winding up, and grows progressively less until the piston is quite down. It is true that there is a regulating arrangement, in the moderator lamp, to make the overflow uniform; but, so far as I have seen, this is not effective, and practically the matter is as I have described. I, however, found that the principle adopted in the moderator, of throwing up the oil to the wick by a mechanical contrivance, was convenient and effective; and I have overcome both the defects which I have described in the lamp, with the kind assistance of Mr. Armstrong, of the firm of Messrs. Gardner, of the Strand. I determined upon fixing the chimney at a definite height, and I overcame the difficulty as to the irregularities of the overflow by making a row of holes one-eighth of an inch in diameter in the wick-holder, half an inch below its upper edge, so that the overflow of oil, instead of taking place over the upper edge, should be half an inch lower down, leaving the oil to be raised from that point to the flame by the capillary attraction in the wick itself. As an improvement upon this plan, Mr. Armstrong suggested that four slots in the wick-holder would provide a better outlet for the superfluous oil than the holes mentioned, and he has made me a lamp in which the slots, which may be seen in the drawing, can be covered by a sliding cylinder of thin metal, so that the overflow can be slightly raised or lowed at the height of about half an inch from the edge of the wick-holder.

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* See "The Journal of Gas Lighting" for March 16th last.

In this arrangement of lamp I believe that I have obtained almost all that can be desired in relation to the lamp *per se*. The next point to be disposed of was that concerning the fuel; and here the limits of inquiry were very narrow, and lay, indeed, practically only between refined rape oil and sperm oil. I believe that a worse or more uncertain material than refined rape or colza oil could not have been proposed for burning as a standard of light. The refining of this is effected by severe chemical treatment. The oil is treated with the strongest sulphuric acid, and the final result is dependent upon several points, of which the manufacturer possesses so little knowledge, and over which he can exercise so little control, that no two batches of refined rape oil can, strictly speaking, be supposed to possess exactly the same burning properties. The age of the seed, the difference in variety of the seed, the quantity of acid used in refining, the strength of the acid, the time the oil is heated with it, and the method used in bring the oil into condition for the market, all affect its quality as burning oil, and give to it an uncertainty of character which renders it unfit for use in producing a standard light. I have already said that I consider only one kind of oil fit for this purpose—that is, sperm oil. In the first place, sperm oil is, among the fixed oils, beyond all comparison the best fuel for lamps. Where refined rape oil can be burned six or eight hours, sperm oil can be burned 15 or 16, even then producing much less of the charring of the wick which other oils produce more or less rapidly, and which reduces the light progressively from the very first. Sperm oil is a natural production in the form in which we have it; it is only filtered to separate from it the solid spermaceti with which it is naturally mixed, and it never undergoes any chemical treatment, so that its constitution is in no wise altered artificially. Various specimens resemble each other so closely that no difference can be detected in their manner of burning, and, what is of great importance, the specific weight of sperm oil is so far removed from that of the other fat oils, that adulteration with inferior oil cannot be carried on without being easily detected. With regard to this point, I may, however, remark that the weight generally set down in books as the specific weight of sperm oil—·8750—is quite inaccurate. I have never had an opportunity of examining a sample with lower specific gravity than ·8790 and the sperm oil to be obtained in commerce possesses a specific weight rising to ·8810. The best sperm oil is known as colonial oil; when used for producing a standard light it should be filtered in the winter, so that the last portions of spermaceti may be removed from it. Such oil should have a specific gravity of ·880, or a little less, and when burned in a common cup lamp, with a few threads of cotton for a wick, it ought to give a bright and even light so long as any of the oil remains.

The dimensions of the lamp in which I propose to burn the sperm oil as a standard are as follows, the body of the lamp, with spring and piston, being that of an ordinary full-sized moderator:—

| | | |
|---|---|---|
| External diameter of the outer tube of the burner ... ... | 1·08 | inch. |
| Internal diameter of inner tube of the burner ... ... | 0·75 | „ |
| Whole height of chimney ... ... ... ... ... ... ... | 9·45 | „ |
| Height to shoulder of chimney outside ... ... ... ... | 2·35 | „ |
| Internal diameter of bottom of chimney ... ... ... ... | 1·90 | „ |
| Internal diameter of top of chimney ... ... ... ... ... | 1·20 | „ |
| Regulator of overflow, mean distance below the edge of outer tube ... ... ... ... ... ... ... ... ... | 0·50 | „ |
| Mean height of flame, burning about 760 grains of oil per hour, about ... ... ... ... ... ... ... ... ... | 2·50 | „ |

The wick used in the lamp is the common sperm oil wick, 1 inch in length, weighing, when dry, 7·60 grains.

Some time since I published, in the "Journal of Gas Lighting," an account of a candle balance adapted to the photometer-bar, so that the weighings of the candles could be made *in situ*. The lamp which I have described is attached to the photometer, and can be weighed with the greatest exactness by a modified and improved form of that balance, as is shown in the woodcut. I have, however, added to the apparatus a table or support, upon which the lamp rests. This table, which is shown in the drawing below the lamp, can be raised or lowered by the rack and pinion, and fixed at the proper height by a screw. The whole weight upon the central knife-edges of the balance is somewhat more than 7lbs., which is reduced to a minimum by the balance being constructed with arms of unequal length; and the balance, which is very simple in its structure, is sufficiently delicate to turn distinctly with about the one hundred thousandth part of the gross weight. The regularity with which this lamp burns is very satisfactory, and it is easy, after a little practice, to start it at once with a consumption of oil approaching closely to the quantity which it is intended that it should burn. The following table shows how little the consumption varies in successive given periods, even when calculated for the whole hour:—

| Quantity of Oil Consumed. | Time in Minutes. | Consumption of Oil Per Hour. |
|---|---|---|
| 100 grs. | 8·06 | 744·4 grs. |
| 100 „ | 8·10 | 740·7 „ |
| 100 „ | 8·25 | 727·2 „ |
| 100 „ | 8·06 | 744·4 „ |
| 100 „ | 8·08 | 742·5 „ |
| 100 „ | 8.07 | 743·4 „ |
| 100 „ | 8·03 | 747·1 „ |
| 100 „ | 8·00 | 750·0 „ |
| 100 „ | 8·00 | 750·0 „ |
| 100 „ | 8·00 | 750·0 „ |

After many experiments, I have fixed the normal consumption of oil in this lamp at 760 grains per hour. Its mean lighting power, burning that quantity of oil, very slightly exceeds 10 standard sperm candles; I have, therefore, adopted it as giving the most convenient constant number which could be obtained. The following table of four sets of experiments shows the lighting power of the lamp, the results being corrected to a consumption of 120 grains of sperm per hour for the candles, and 760 grains of oil per hour for the lamp:—

*First Series.*

| | | | |
|---|---|---|---|
| Experiment 1 | Lamp equalled | 9·84 | candles. |
| „ 2 | „ „ | 10·07 | „ |
| „ 3 | „ „ | 9·82 | „ |
| „ 4 | „ „ | 9·97 | „ |
| Mean | | 9·92 | „ |

*Second Series.*

| | | | |
|---|---|---|---|
| Experiment 1 | Lamp equalled | 10·13 | candles. |
| „ 2 | „ „ | 10·10 | „ |
| „ 3 | „ „ | 10·13 | „ |
| „ 4 | „ „ | 10·43 | „ |
| Mean | | 10·19 | „ |

*Third Series.*

| | | | |
|---|---|---|---|
| Experiment 1 | Lamp equalled | 10·09 | candles. |
| „ 2 | „ „ | 9·93 | „ |
| „ 3 | „ „ | 10·07 | „ |
| „ 4 | „ „ | 9·99 | „ |
| Mean | | 10·02 | „ |

*Fourth Series.*

| | | | |
|---|---|---|---|
| Experiment 1 | Lamp equalled | 9·98 | candles. |
| „ 2 | „ „ | 10·00 | „ |
| „ 3 | „ „ | 10·00 | „ |
| „ 4 | „ „ | 10·02 | „ |
| Mean | | 10·00 | „ |

General mean upon the four series 10·03 candles.

This number is so little removed from 10 that, practically, the latter may be taken to represent exactly the standard of light according to my proposition, and the adoption of such a number affords great facility in adapting the new standard to the present photometric scale. Of course, if candles cease to be the standard of light in estimating the value of illuminative gas, it would be irrational to continue to express such value in candle power; a different system of scale on the photometer ought then to be adopted, taking 1, 10, or 100 as the starting-point of the scale. But at the outset it would be useful, supposing the lamp to be found a desirable standard, to be able to adapt it to the present photometric scale; and this can be done without difficulty, so soon as the real value of the lamp is ascertained in candles. This number, whatever it may be, is a constant; to arrive at the lighting power of the gas, it is only necessary to multiply the result read off in candles on the photometer, by the constant number of the lamp, to obtain the value of the gas expressed in candles. If the power of the lamp be taken at 10 candles, as I have suggested, no calculation will be required; it will then only be necessary to move the decimal point of the reading in candles on the photometer one place to the right to find the correct final expression of value. Thus, 1·01 becomes 10·1 candles; 1·10 becomes 11·0 candles, and so on. The only change necessary in the photometer scale would be the further division of the 10ths of candles into 10ths, which would then represent 100ths of a candle. I am informed that a photometer scale graduated in this manner was first made by Mr. Hartley for a candle photometer, but in the case of the substitution of the greater light of the lamp such a division of the scale is an obvious necessity.

A glance at the drawing which accompanies this article will show at once the arrangement and mode of action of the apparatus described.

The lamp is arranged *in situ* at the end of a common bar photometer. The knife-edges at the forked extremity of the balance suspend it by means of a collar with lateral steel plates, which are slightly hollowed, and which rest on the knife-edges. The table, which can be raised and lowered by a rack and pinion, is seen below the lamp. The course of an experiment is simply as follows:—The lamp, being burning at its proper rate, is put in its place on the balance, and the table brought to such a height that when the weights in the counterpoise are properly adjusted the beam will be a little depressed at the lamp end. As the oil burns away, the lamp, of course, becomes proportionately lighter, and in a short time the lamp end of the balance will begin to rise, and the weight to pass over to the distal end. As the index passes the zero of the scale, the time must be noted, as this is the commencement of the experiment. The weight which is to represent the consumption of oil in any given time through which it is intended that the experiment should last, must next be placed upon the little shelf made in the shoulder of the lamp, and the effect of this will be to render the lamp again heavier than the counterpoise, so that it will be brought back upon the table, where it will remain firmly seated until the experiment is completed. When it is expected that the oil represented by the weight is about to be exhausted, the balance must be again watched, and the time taken as the index passes over the zero the second time; this gives the time of the consumption of a given weight of oil, and from this the lighting power of the lamp must be rectified to a consumption of 760 grains of oil per hour, according to the general practice. In all other respects the experiment is conducted as an ordinary photometric experiment with the candles, the only difference being that, having obtained the reading of the scale in candles, the result must be multiplied, as I have already explained, by the constant number of the lamp, to bring the expression of the lighting power of the gas up to its actual value.

## SHIPBUILDING IN ITALY.

Italy is well supplied with materials for shipbuilding. Excellent timber is furnished by the forests of the Alps, Apennines, the Tyrol, and of the island of Sardinia. The mines of the Isle of Elba give an inexhaustible supply of the best iron, and in Lombardy the workers in this metal have been famous for many centuries. In Tuscany and on the Ligurian coasts several copper mines are in active operation, and the best hemp in the world is grown in the valley of the Po. Abundantly supplied with the raw material, and with a seaboard of 3,622 English miles, Italy must necessarily be one of the most important shipbuilding countries in the South of Europe; and since the formation of a United Kingdom this important branch of industry has greatly increased.

Previous to 1859 the total number of vessels launched throughout the Peninsula did not exceed 200, measuring, collectively, 34,000 tons yearly. In 1867 the number of vessels launched was 642, measuring collectively, 72,257 tons from 80 ship-yards.

The vessels launched from the shipbuilding yards at Sestri Ponente, Varazze, and Savona alone made up one-half of the aggregate tonnage during 1867.

The average tonnage of those built on the Ligurian coast—viz., at Loano, Pietra Ligure, Voltri Pra, Recco, Lavagna, Spezia, and at Lerici —exceeded 500 tons each. With the exception of Castellamare, where two vessels of over 300 tons burden were launched, the vessels built at the other yards were of small size. The number of vessels built, classed according to tonnage, were as follows:—

| | Vessels launched, No. | total tonnage |
|---|---|---|
| Between 500 and 900 tons ... ... ... ... | 58 | 33,848 |
| „ 100 „ 500 „ ... ... ... ... | 93 | 33,035 |
| „ 60 „ 100 „ ... ... ... ... | 30 | 2,185 |
| „ 30 „ 60 „ ... ... ... ... | 20 | 857 |
| Under .. 30 tons ... ... ... ... ... | 441 | 2,332 |
| Total ... ... ... ... | 642 | 72,257 |

The largest vessel launched during the year was a barque of 875 tons, at Chiari, the cost of which was 350,000f. The total value of the ships built during 1867 was 21,915,140f., including those built at Venice for a value of 1,056,700f.

At Genoa there is a graving dock and patent slip. A graving dock also is opened at Naples. Others are in construction at Messina and Ancona, and Brindisi and Venice will not remain long without them. The two largest ironworks in the kingdom are at Naples and Genoa—at the former the Pietrarsa works, and at the latter those of Sampierdarena, capable of making the largest marine engines. There are also smaller establishments at Palermo and Venice. An iron shipbuilding establishment is also opened at Leghorn. The best sail cloths and rope are manufactured at the ports of Genoa, Castellamare di Stabia, Ancona, Palermo, Messina, and Venice.

DIFFICULTY is often experienced in turning certain metallic alloys (as those of zinc copper, and tin) in a lathe, owing to their extreme hardness and the readiness with which the cutting tools become blunted. It has, however been ascertained that if the point of the tool, while in use, be kept constantly moistened with petroleum, the work will proceed as readily as with red-hot metal. Steel tempered to a light yellow has been turned with the greatest facility by using a mixture of two parts of petroleum and one of oil of turpentine.

## TRIAL TRIP OF THE STEAMSHIP "HINDOSTAN."

On the 16th ult., the opium clipper steamer *Hindostan*, built for Messrs. Asscar and Co., of Calcutta, by Messrs. J. Wigham, Richardson, and Co., of Newcastle-upon-Tyne, and engined by Messrs. Thompson, Boyd, and Co., was tried at the measured mile, and attained a speed of 12½ knots, on a mean draught of water of 17ft., and the impression was that had the vessel been 15in. by the stern, a much greater speed would have been attained. The cylinders of this vessel's engines have a diameter of 64in., with a three-foot stroke, and developed an indicated horse-power of 1,440. They are fitted with surface condensers, and all the best arrangements for economising fuel. The circulation of the water in the condensers is effected by a centrifugal pump, made by Messrs. J. and H. Gwynne, of Hammersmith, which gave a most satisfactory result. The dimensions of this splendid steamer are:—Length, 300ft. 6in.; breadth, 35ft. 2in.; depth, 22ft. 6in. There were on board the representatives of the owners, who appeared in every way satisfied with the vessel's performance, and her yacht-like model called forth many compliments to Captain R. B. Durham, who has had the entire designing, planning, and superintendence of the vessel and her machinery. The saloon is fitted to accommodate forty first-class passengers, and, together with the sleeping berths, is most elegantly furnished and decorated; and every care appears to have been taken to adapt everything to the climate for which the vessel is intended. From her trial we may look with confidence for a very rapid passage of the vessel out to India. She is expected to leave the Tyne for Calcutta on the 19th inst., and on her arrival out the residents of the far East may consider such an addition to the available means of transit a very great boon. She is intended to leave Calcutta, with her sister ship, *The China*, now on the stocks, after each alternate opium sale, for China. The owners of this steamer having already had several others built by Messrs. J. Wigham, Richardson, and Co., seem to give the Tyne a preference over either the Thames or the Clyde, and it is somewhat satisfactory to know that the builders on that river have established such confidence.

## PADDLE *v.* SCREW.

A striking instance of the proper distribution of steam-power has been exemplified in a steamer recently altered at the port of Greenock. The vessel in question was a paddle-steamer of 350 horse-power, with cargo space for 400 tons of goods. Her consumption of fuel was 24 tons a-day and her speed 7½ knots. She was converted into a screw-steamer, and fitted with a twin propeller, and the consequence has been that with engines of 75 horse-power she steams at the rate of 10½ knots, and carries 800 tons of cargo, with a daily consumption of about 8 tons of coal only.

## REVIEWS AND NOTICES OF NEW BOOKS.

*A Residence in Bulgaria; or Notes on the Resources and Administration of Turkey.* By S. G. B. St. Clair, late 21st Fusiliers, and Charles A. Brophy. London: John Murray, Albemarle-street. 1869.

Now that Hungary is about to be opened up more thoroughly by the construction of an immense network of railways, and that the trans-Danubian countries of Servia, Bosnia, and, above all, Bulgaria—of which, as yet, comparatively so little is known by the English traveller—will be shortly invaded by railway engineers, surveyors and contractors, a more opportune publication could not have been given to us.

Not only does Bulgaria possess great charms for the tourist, but it offers one of the finest virgin soils, for the pursuit of commerce and industry. To the English engineer, geologist, and mineralogist, we can vouch that it offers an amount of real interest, such as, in the present period of stagnation which exists throughout the profession generally, might be most profitably taken advantage of.

The authors have thoroughly succeeded in making a very interesting book, and have thrown more light upon the internal political, social, and commercial condition of Bulgaria than has ever yet been done by the writers who have previously essayed the task. They possessed in themselves peculiar qualities for enabling them to pursue their inquiries independently of the extraneous aid either of a dragoman, or of interested tale bearers, by their perfect knowledge of the languages spoken in the country. They were, therefore, enabled to travel without escort, and thus they have not only acquainted themselves with this magnificent country, but with its people and their actual condition.

The dedication of the book is very appropriately made to one of the very ablest of Her Majesty's Consuls General, John Augustus Longworth, of Belgrade, upon whom Her Majesty has recently been pleased to confer the honour of Commander of the Bath; whose great courtesy is only equalled by his high courage, and his political talents and diplomatic ability by his high sense of honour, truth, and justice.

[We have received several books, notices of which are unavoidably postponed until our next.]

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

Method for Sharpening old Files.—The files are first washed with a hot lye of soda, and all grease removed with brushes. They are then suspended in a mixture of concentrated nitric acid with eight parts by measure of water for 25 minutes; then well cleaned in water with brushes, and re-immersed for 25 minutes more in the acid mixture with addition of another eighth of strong acid. Brush again and re-immerse, after adding to the bath a sixteenth part of concentrated sulphuric acid. This heats the bath, and the etching proper now commences, and is kept up for three minutes, with a vibratory motion of the bath. Wash and brush and reimmerse in a bath similar to the last with similar agitation for five minutes. Wash repeatedly with water, then with milk of lime; finally rinse again with water, dry quickly at a gentle heat and varnish, while still warm, with oil.

The experiment of drawing a train by an engine heated with mineral oil has been tried in America with alleged success. All the gradients, some of which were very steep, were ascended with the greatest facility.

Experiments recently made at Chenoa, Illinois, in drying corn by hot air, and thereby getting it to an early market, and obtaining the first prices of the season, are, it is said, repaid by a perfect success. Two drying-houses are already in operation, and another will be added.

The Tower Subway.—This work is now in course of construction under the bed of the river, from Tower-hill to Tooley-street, and consists of a tunnel less than a quarter of a mile in length, access being gained to it by a shaft at each end. The depth of these shafts will be 52ft. and 60ft. respectively, in which it is proposed to have plumb lifts for the transit of passengers, parcels, &c., to and from the subway, through which an omnibus running on steel rails is propelled, both being worked by steam power. In driving the "Subway," which will be about 22ft. below the bed of the river, a wrought iron shield will be employed overlapping the tunnel, provided with doors in the front through which workmen can drive the heading, but which can be immediately closed on any appearance of water, and so render all water-tight; this shield will be propelled by powerful screws, and, as it progresses, the tunnel segments inserted. The whole of the work is under the superintendence of Mr. Peter W. Barlow, jun., C.E., the engineer, the contractor being Mr. J. H. Greathead, under whose superintendence the shafts are now being sunk by Mr. Thos. Tilley, artesian well engineer. The castings for these shafts and the tunnel, which are all made in segmental rings firmly bolted together, as also the manufacture of the shield, are entrusted to the firm of Messrs. Bells, Goodman, and Co., of Newcastle-upon-Tyne and London. The "Tower Subway" was commenced on the 16th of last February, and as the shaft for the Middlesex side is already sunk to the depth of 60ft. and the remainder of the work well advanced, it is expected to be opened to the public before the commencement of the year 1870.

The Chicago *Journal of Commerce* says, a man in Des Moines, Iowa, has erected a dwelling house for himself, built mostly of paper. The weather boarding, inside walls and shingling are of that material known in the West as the "Rock River Company's Building Paper." The cost is about two-thirds that of the ordinary materials, and the house, it is said, is much warmer than where plaster and wood are used.

### NAVAL ENGINEERING.

An order has been issued from the Admiralty that all ships of war carrying twin-screw engines are to have their machinery fitted with Silver's steam governor. The largest vessel driven by twin-screws in Her Majesty's navy at present in commission is the armoured iron frigate *Penelope*, 3,096 tons, 600-horse power. The official reports from this vessel are highly favourable as regards the beneficial action of the steam governor at sea, and especially so in rough weather.

### MILITARY ENGINEERING.

The North German correspondent of the *Times* says that a new rifle invented by Meyhöfer, in East Prussia, seems to be by far the most formidable weapon in existence. Charge and discharge appear to take place almost simultaneously, and it is said 30 shots can be fired from it in a minute. At the moment when the barrel is closed by a valve, the cartridge is exploded by means of a small knife. This new weapon weighs only 8½lb. and the barrel has a length of 36in.; the cartridges are of paper, which besides being cheap, cannot expand and stick fast in the barrel, as was the case with the American rifle tried in St. Petersburg. The long arrow-shaped projectile of the Meyhöfer rifle is fatal at 1,800 paces, and weighs only two-thirds of a pound, so that every soldier in the field can carry with him 100 cartridges. The new rifle is loaded by a gentle blow of the flat of the hand on the handle of the valve, which opens the powder chamber for the entrance of the cartridge.

### STEAM SHIPPING.

Trial Trip.—The paddle steamer *Mahoud Pacha*, lately launched by the Messrs. Hamilton, at Greenock, proceeded down the Clyde on the 6th ult. on her official trial trip. The *Mahoud Pacha* is a fine wooden steamer. Her engines oscillating and of 100-horse power, were constructed by Messrs. Daniel Rowan and Co., of Glasgow, and are highly finished. In running the lights she attained a speed over 15¼ knots per hour. She has been built for the Ottoman government, and is the first of three similar vessels.

The Steamship "Washington."—The *Washington*, a large ocean paddle steamer averaged but 10 knots and burnt 96 tons of coal per 24 hours. Since changed into a twin-screw steamer, but with no alteration in the hull or boiler, she averaged 11·8 knots, with a consumption of 83 tons of coal daily.

Two large steamers, each 246ft. long, have just been despatched from New York to China. They are to sail on the Yangtse river.

### LAUNCHES.

Messrs. A. Stephen and Sons, of Kelvinghaugh, have launched a screw steam yacht of 350 tons; built for Mr. Lamont, of Knockdow. The yacht is to be employed for yachting and scientific purposes in the Arctic Seas.

On the 10th ult. there was launched from the shipbuilding yard of Mr. John Elder, at Fairfield, Govan, the *William Millar*, an iron screw steamship, of 800 tons builders' measurement. The engines, which are of 120 horse-power, are being fitted by the builder, on his patent compound principle. The *William Millar* has been built to the order of Donald R. McGregor, Esq., and is intended for the Baltic and Mediterranean trade.

A new steamer, the *Leo*, the property of Messrs. T. Wilson, Sons, and Co., was launched on 1st ult. at Hull. She was built be Messrs. C. and W. Earle, and her dimensions are—length, 221ft.; beam, 30ft. 6in.; depth of hold, 17ft.

Messrs. Barclay, Curle, and Co. launched on the 30th March, the *Sweden*, a handsome spar-decked iron screw steamer, of about 1,000 tons register. She is intended by her owners, Messrs. J. and A. Allan, of Glasgow, to form one of their newly established line of steamers between Norway and Newcastle, and she will be fitted and finished similarly to the *Norway*, also built by Messrs. Barclay, Curle, and Co., which left the Clyde a few weeks ago to take her place on the same station. The *Sweden* is in length 235ft., in breadth 30½ft., and in depth 17ft. Her propelling power will be supplied by direct-acting surface-condensing engines of 120-horse power.

A handsomely-modelled iron screw steamer was launched on the 31st March from the iron shipbuilding yard of Messrs. Schlesinger, Davis, and Co., at Wallsend. This vessel, which was named the *Malvina*, has been specially constructed for the Danube and Black Sea trade, and is built to the order of a firm in Constantinople. The dimensions are:—Length, 170ft.; breadth 26ft.; and depth, 15¼ft.; burthen 600 tons, and class Ac at Lloyd's. The *Malvina* will be furnished with engines of 70-horse power, of the surface-condensing class, by Messrs. Thomas Clark and Co., of the Elswick Marine Engine Works, Newcastle.

## RAILWAYS.

On March 30th Colonel Hutchinson, R.E., Government Inspector, went over the North Eastern extension line, and the new and commodious joint station of that company, and the London and North-Western, and passed them for traffic. In consequence of this official approval the trains of both companies on the 1st April ran into the new station, instead of, as heretofore, into the Wellington station, which the companies have used for so many years past.

There are only seventy-five miles of rail remaining to be laid on the Pacific Railroad, and it is expected that a locomotive will run through to San Francisco early in the summer. The highest point on the road is 7,500ft. above the sea.

The exports of rail from Belgium decreased last year to 70,550 tons, as compared with 80,875 tons in 1867. The diminution in the exports of rails arose principally on Russian account.

## DOCKS, HARBOURS, BRIDGES.

The Hudson River suspension bridge will use up 70,302 miles of steel wire .

## MINES, METALLURGY, &c.

The Northumberland Steam Collieries.—The steam coal trade of Northumberland, which had been in a depressed state several months, is recovering, and there is an increased demand. According to a determination come to by the Admiralty to consume in future Welsh and north country coals in equal proportions, a Government official has been down in the North and has examined the quality of the coals at the several collieries, and a considerable order has been given through him. Instead, however, of the Government having a list of pits from which they took their supplies, as under the old system, they deal in the open market, and immediately with the colliery owners, instead of employing agents, through whom they sent their orders. The Admiralty have given instructions that the bars of the furnace of the steamships in the Royal Navy be altered according to the plans prepared by Mr. T. W. Millar, of the Devonport Dockyard, which it is anticipated will make the consumption of north country coal smokeless. The *Weardale*, screw collier, is fitted up with Mr. Millar's apparatus. She consumes north country steam coals exclusively, with smokeless results.

The *Iron and Coal Trades Review* refers to an important change about to occur in one branch of the iron business, from the termination of the Bessemer patents. The principal part of these patents expires next year, but Mr. Bessemer, it is said, has patented so many of the appliances, blowing engines, valves, and combinations that he will have claims for royalties for several years after the lapse of the patents which are absolutely essential to the process with which his name is identified. It is understood, however, that after conferring with his leading licensees he has signified his willingness to reduce his royalties from their present high rate of £2 per ton on everything (except steel rails, for which a rebate of 20s. per ton of finished rails is allowed) to a charge of 2s. 6d. per ton. This it is added, will practically reduce the price of ordinary Bessemer steel £2 per ton, and rails about 30s. per ton, so that the manufacturers of iron rails have before them the prospect of seeing steel rails in the market at £9 per ton, in the course of another year or so. The margin between iron and steel rails will then be so small that it is easy to see that a great impetus will be given to the steel rail trade, and should no difficulty be experienced in obtaining the necessary supplies of pig iron suitable for conversion into Bessemer steel, it is hard to say how far the development of the manufacture of cheap steel will be carried.

## APPLIED CHEMISTRY.

The *Scientific Review* says—"Professor Silvestri informs us that some experiments he has recently made, lead infallibly to the conclusion that hydrogen and oxygen can combine directly at the ordinary temperature of his laboratory in Catania." Further particulars are promised.

Professor Tomlinson has prepared a long and interesting paper on the action of solid nuclei in liberating vapour form boiling liquids. The learned author reviews the researches of several other philosophers, gives us the latest results of his own researches on this subject, and arrives at the following remarkable conclusions, viz., that a liquid, at or near its boiling point, is a supersaturated solution of its own vapour. Next, that a solid non-porous nucleus either is or is not efficient in liberating vapour, according as it is chemically unclean or clean. Finally, that as porous bodies do not become inactive, the proper nucleus for liberating vapour in the operations of boiling, and distilling, and for preventing bumping, is charcoal, coke, or some other porous body.

According to a German journal, an excellent permanent black ink may be made from the common elder. The bruised berries are placed in an earthen vessel and kept in a warm place for three days, and then pressed out and filtered. The filtered juice is of such an intense colour that it takes 200 parts of water to reduce it to the shade of dark red wine. Add to 12½ quarts of this filtered juice, one ounce of sulphate of iron and the same quantity of pyroligneous acid, and an ink is prepared which, when first used, has the colour of violet, but when dry is indigo blue black. This ink is superior in some respects to that prepared with galls. It does not become thick so soon; it flows easier from the pen without gumming; and in writing the letters do not run into one another.

Ebullition of Water.—(*Poggendorff's Annalen.*)—In reference to the well-established fact that water, after having been deprived of air as much as possible, either does not boil at all when heated, or does so with violent sudden starts and concussions, some experiments have been made by Kremers, who observed that, in order to assist in expelling air from water, the addition of spirit of wine, in the proportion of one part of the latter to three of the former, is very useful. He cautions against a danger which exists when such a mixture is heated too rapidly, since it is very apt to boil over, especially after a portion of the spirit has evaporated. It is rather curious that, though both the water and spirit of wine employed were pure, the mixture, when boiling, should assume a greenish yellow hue, which disappears again on cooling; the boiling point of the fluid easily becomes as high as 100° C. As a result of a large number of experiments, the author finds that water, as fully deprived of air as possible may be heated as high as from 180° to 200° C., without boiling permanently.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| **COPPER.** | | | | | | |
| Best selected, per ton | 79 | 0 | 0 | ,, | ,, | ,, |
| Tough cake and tile do. | 77 | 0 | 0 | 78 | 0 | 0 |
| Sheathing and sheets do. | 80 | 0 | 0 | 82 | 0 | 0 |
| Bolts do. | 81 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 83 | 0 | 0 | 84 | 0 | 0 |
| Old (exchange) do. | 65 | 10 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 81 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7 | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6¾ | ,, | ,, | ,, |
| **SPELTER.** | | | | | | |
| Foreign on the spot, per ton | 21 | 12 | 6 | 21 | 0 | 0 |
| Do. to arrive | 21 | 1 | 0 | ,, | ,, | ,, |
| **ZINC.** | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | ,, | ,, | ,, |
| **TIN.** | | | | | | |
| English blocks, per ton | 130 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 131 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 136 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 138 | 10 | 0 | ,, | ,, | ,, |
| Straits do. | 132 | 0 | 0 | ,, | ,, | ,, |
| **TIN PLATES.*** | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 8 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 14 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 7 | 0 | 1 | 8 | 0 |
| IX. do. 2nd quality do. | 1 | 13 | 0 | 1 | 14 | 0 |
| IC. Coke do. | 1 | 5 | 0 | 1 | 6 | 0 |
| IX. do. do | 1 | 11 | 0 | 1 | 12 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| **IRON.** | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 10 | 0 | 6 | 15 | 0 |
| Do. to arrive do. | 6 | 12 | 6 | 6 | 15 | 0 |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 12 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 0 | 0 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. merch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 13 | 3 | 3 | 0 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| **STEEL.** | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| **LEAD.** | | | | | | |
| English pig, common, per ton | 19 | 10 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 5 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 17 | 6 | 19 | 0 | 0 |

*At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated March 18th, 1869.

831 W. T. Sugg—Gas burners
832 A. B. Walker—Producing and applying heated air to various purposes
833 J. Ritchie—Fly wheels
834 J. Cox—Velocipedes

### Dated March 19th, 1869.

835 E. A. Inglefield—Steering apparatus
836 J. Thomas, W. Bacon, and H. Groves—Manufacture of iron, &c.
837 F. W. Fox—Locomotive engines
838 A. Albini—Revolving firearms
839 C. G. Bonehill—Breech-loading firearms
840 J. Jack—Construction of ships, &c.
841 E. T. Hughes—Scales
842 S. Fox—Permanent way of railways
843 A. V. Newton—Obtaining motive power
844 W. R. Lake—Overshoes
845 C. E. Brooman—Use of petroleum and other oils for heating
846 S. R. Wybrants—Textile fabrics

### Dated March 20th, 1869.

847 J. Hamilton and R. Paterson—Apparatus for containing aerated beverages
848 F. D. Nuttall—Furnaces
849 J. D. Morrison—Heating buildings, &c.
850 H. Whitehouse and W. Probert—Tuyeres for blast furnaces
851 F. Holmes—Blind cords
852 W. L. Wrey—Toothed gearing
853 J. V. Robinson—Negatives for photographic printing, &c.
854 F. E. Duckham—Governors
855 J. Kay—Wind instruments
856 H. E. Newton—Measuring liquids
857 H. E. Newton—Engines

### Dated March 22nd, 1869.

858 W. H. Phillips—Extinguishing fires
859 W. R. Lake—Hay-tedding machine
860 J. Booth—Indexes of books
861 J. Loader—Injecting water
862 G. Lauder—Twisting tobacco
863 T. Carrodus—Self-coupler
864 W. G. Crossley—Wheels
865 W. Crossley and J. W. Swithenbank—Shuttles
866 E. G. Reuss—Cutlery
867 H. Vansittart—Screw propellers
868 J. Combe and J. Barbour—Transmitting rotary motion, &c.
869 M. Tildesley—Door bolts
870 E. Stacey and J. Thomson—Method of purifying gas
871 M. Sigler—Looms
872 J. J. Hicks—Stoppers for bottles
873 J. E. Emerson—Chairs
874 G. T. Bousfield—Felt cloths
875 A. Clark—Mixing paint

### Dated March 23rd, 1869.

876 J. Nicol—Envelopes
877 R. Gregson—Firebars
878 G. Blanche—Attaching purses to the pockets or clothing
879 C. Longfield—Cramps for flooring boards
880 J. Macintosh—Elastic fillets, &c.
881 L. A. Israel—Sulphuric acid
882 C. De Bergue—Making holes in metal
883 J. Fryer—Rotary cultivator
884 J. H. Johnson—Artificial stone
885 F. Rudrum—Velocipedes
886 J. Horsley—Protecting nitro-glycerine
887 F. De Bowens—Match splints

### Dated March 24th, 1869.

888 M. F. Maury—Heating railway carriages
889 J. B. Fell—Locomotive engines, &c.
890 R. W. Page—Garden engines
891 W. Harrison—Sunshade
892 C. McDermott—Press for applying combined eyelets and paper fasteners
893 F. J. Manceaux—Firearms
894 V. Chemery—Damping cloth
895 J. Nevill—Securing window sashes, &c.
896 W. E. Newton—Working heavy guns
897 A. Clayton and J. Riley—Firearms
898 T. Shakespear and G. Illston—Improvements in sewing machines
899 C. B. Parkinson, A. Metcalf, J. Metcalf, and W. H. Heald—Mules
900 F. Baker—Locking railway point and signal levers
901 J. Woodhead—Flooring cramps
902 W. J. Cunningham and A. McCarthy—Motive power
903 E. Peyton—Rollers for printing upon textile fabrics

### Dated March 25th, 1869.

904 W. R. Lake—Folding paper
905 J. J. Bodmer—Iron and steel
906 F. Hurd—Excavating coal
907 J. R. Baillie—Waggons
908 J. H. Johnson—Iron and steel
909 T. Champion—Flues
910 J. T. Greenfield—Side arm
911 T. Baker—Fire escapes
912 W. C. Dreyer—Tilling land
913 J. T. Calow—Safety apparatus applicable to cages or hoists
914 C. Marsden—Pipes and tubes
915 W. R. Lake—Pressing oil, &c.
916 W. Meakin—Window sashes
917 W. R. Lake—Electro-magnetic machine
918 T. Sowden—Bobbins
919 H. A. Bonneville—Electric clock

### Dated March 27th, 1869.

920 A. C. Kirk—Cooling liquids
921 J. Macintosh—Working guns
922 H. Downie and I. B. Harris—Improvements in shoes for horses
923 W. B. Gedge—Box for holding matches
924 G. Dymond—Baking powder
925 L. Hannart—Muzzle for dogs
926 G. Hodgson, H. Bottomley, and E. Cockroft—Looms
927 J. J. Bagshawe—Grinding Flour
928 N. Voice—Greenhouses, &c.
929 H. Haschke—Firearms
930 D. Jones—Buckets, &c.
931 F. Parker—Locomotive engines
932 J. Jacquillard—Musical boxes
933 B. J. B. Mills—Extracting oleaginous matter from vegetable substances, &c.
934 J. W. Girdlestone—Constructing ships
935 E. H. Hirch—Storing meat, &c.
936 W. Riddell and T. Bletcher—Improvements in sewing machines

### Dated March 29th, 1869.

937 F. B. Taylor—Numerical counting and recording machine
938 G. Bloem and E. Scheidt—Breech-loading firearms, &c.
939 W. R. Lake—Soda and potash
940 W. R. Lake—Blowing apparatus
941 W. R. Lake—Horse shoe nails
942 E. Morewood—Coating metals
943 S. Firth—Picks and railways for cutting coal and other minerals
944 A. Clark—Stereoscopes
945 W. P. Hope—Cement kilns

### Dated March 30th, 1869.

946 G. T. Bousfield—Sewing machines
947 C. Weekes—Firewood
948 J. Bith—Pencil cases
949 H. G. Dixon—Velocipedes
950 W. W. Harris—Velocipedes
951 A. Muir—Velocipedes
952 M. McLeod—Railways
953 C. E. Brooman—Winding threads, &c.
954 A. Barclay—Steam boilers
955 J. Briggs and J. Almond—Looms
956 T. E. Williams—Method of distilling hydrocarbon oils
957 W. F. Proctor—Sewing machine table
958 F. Render—Railways
959 T. G. Webb—Melting furnaces
960 H. Y. D. Scott—Lime kilns
961 W. E. Cadman—Decorating surfaces

### Dated March 31st, 1869.

962 A. Chambers—Carriages, &c.
963 B. Dobson and J. Eastham—Improvements in carding engines
964 F. W. Follows and J. Bate—Lawn mowing machines
965 T. A. Dillon—Utilising the waste steam of locomotive engines
966 T. Greenwood and J. Keats—Manufacture of boots, &c.
967 A. F. Baird—Earth closets
968 R. Johnson—Wire fences
969 G. Wells—Separating copper and bismuth from ores, &c.
970 J. H. Lloyd—Working tools, &c.
971 H. Davey—Hydraulic machinery
972 W. Langer—Cigars
973 B. J. B. Mills—Envelopes
974 T. Corbett, Carts, &c.
975 B., H., and J. N. Craven—Brick and tile pressing machine
976 J. Livesey—Permanent way of railways
977 J. A. and J. Hopkinson—Indicators
978 R. Jones—Preservation of animal and vegetable substances
979 W. E. Gedge—Fastening belts
980 J. B. Gridley—Paper pulp
981 T. Lippiatt—Engraving

### Dated April 1st, 1869.

982 J. C. Lee—Collecting excreta
983 C. Lange—Winding mechanism of watches and clocks
984 H. Carter and G. H. Edwards—Breech loading firearms
985 G. Holcroft and W. N. Dack—Improvements in steam engines
986 J. Beckett and A. W. Field—Self acting break for railway carriages
987 E. O'Connell—Supplying nourishment to infants, &c.
988 J. B. Rowcliffe—Wire cloth
989 C. D. Norton—Shoe heels
990 T. Higgins—Hats
991 J. Capinu—Umbrellas
992 W. Gibson—Cramp keys
993 G. H. Wilson and G. E. Pullen—Securing window sashes
994 W. Allan—Steam engines
995 W. Bayne and O. E. Macgregor—Carpenters planes

### Dated April 2nd, 1869.

996 G. H. Smith—Indicating when eggs, &c., are sufficiently cooked
997 J. Bath—Printing press
998 H. A. Fletcher—Steam generators
999 W. Marston—Bolts
1000 F. Schafer—Covers for vessels
1001 J. Cruttenden and T. Wells—Facilitating voting by ballot
1002 W. Y. Craig and S. P. Bidder—Improvements in safety lamps
1003 D. Osborn—Concrete building
1004 S. K. Hoxsie—Boat elevators

### Dated April 3rd, 1869.

1005 G. H. Ellis—Cleaning boots
1006 M. Wulfsky—Locks for bags
1007 R. Allan—Paper
1008 D. Nicoll—Safe for food
1000 E. Wilson—Velocipedes
1010 W. H. Douglas—Jet ornaments
1011 J. Howden—Preventing escape of heat from surfaces of cylinders, &c.
1012 U. Scott—Railway carriages
1013 W. E. Broad—Railway wheels
1014 G. F. Griffin—Permanent way of railways and tramways
1015 D. J. Hoare—Atmospheric railways
1016 S. Sharrock—Roofs
1017 F. Boyd—Firearms
1018 F. W. H. Medhurst—Lamps
1019 J. G. Tongue—Parasols, &c.

### Dated April 5th, 1869.

1020 G. A. Ermen—Firearms, &c.
1021 W. Johnson—Compressing carbonaceous combustible substances
1022 J. Woods, J. Hampson, L. Fish, and G. Fish—Looms
1023 J. U. Askham—Anvils
1024 J. Fletcher—Fire bars
1025 F. Commasi—Motive power
1026 W. G. White—Iron safes
1027 W. Jones and T. Sheffield—Boilers for generating steam
1028 J. Winter—Filling glass bottles and jars with soup, &c.
1029 C. Cairns—Heating by steam
1030 J. W. Drummond—Looms
1031 J. Greenslade—Traction engines
1032 J. Sterriker—Pressing apparatus

### Dated April 6th, 1869.

1033 G. T. Bousfield—Paper, &c.
1034 G. T. Bousfield—Shafts of carriages
1035 F. L. Villepigue—Piercing or boring holes in rock, &c.
1036 A. Helwig—Sewing machine
1037 J. M. Johnson—Lavatories, &c.
1038 E. O'Brien—Beam balance
1039 R. B. Hooper, T. Nickson, and H. R. Nickson—Fastening wood sheathing to the bottoms of iron ships, &c.
1040 A. V. Newton—Baking oven
1041 A. K. B. Granville—Beating engines

### Dated April 7th, 1869.

1042 W. Goodreds—Furnace doors
1043 J. Mason—Breech loading guns
1044 W. T. Rickard—Cements
1045 R. Norfolk—Casting screw threads on the naves of wheels
1046 G. S. Chase—Gas
1047 E. Collard—Ladies bustles
1048 W. E. Gedge—Ventilating apparatus
1049 H. B. Barlow—Caskets for jewels
1050 W. R. Lake—Permanent way
1051 J. and J. Menzies—Shuttles
1052 J. H. Teale—Putting on or taking off boots and shoes
1053 B. McEvoy—Improved game
1054 J. Robbins and J. Allbutt—Pumps for raising liquids
1055 W. Powell—Firearms
1056 W. H. Douglas—Glove fasteners
1057 W. H. Douglas—Sleeve link
1058 G. Ashcroft—Hydraulic presses
1059 W. H. Balmain—Preparation of certain oxidising agents, &c.
1060 L. Mond—Utilising soda waste
1061 W. E. Newton—Steam generators
1062 W. T. Eley—Cartridge cases
1063 C. E. H. C. Healey—Cleaning firearms

### Dated April 8th, 1869.

1064 J. W. Warman—Reduction of the distances apart of the levels of the manual of an organ, &c.
1065 J. I. Sinssen—Velocipedes
1066 A. H. Brandon—Joining leather, &c.
1067 H. Parslow—Appliance for designing certain parts of apparel
1068 A. Stewart and J. Wotherspoon—Cutting metal tubes
1069 R. W. Munro—Markers for whist
1070 J. Pattinson—Utilising ammonial skimmings, &c.
1071 D. and G. Hallas—Purifying gas
1072 J. A. Chaufourier—Cotton gin
1073 A. Fryer—Sugar
1074 W. T. C. Pratt—Signalling on railways

### Dated April 9th, 1869.

1075 G. D. Hughes and A. H. Sellers—Safety valves
1076 J. Aspinall—Construction and protection of telegraph cables
1077 W. A. Hunter—Lighting lamps
1078 T. Culpin—Reaping machines
1079 J. A. Miller—Steam boilers
1080 J. Denis—Cutting cogs of wood
1081 R. J. Morison—Presses
1082 R. J. Colls and A. E. Bull—Fastenings for boots
1083 J. Dewar—Food and manure
1084 C. J. F. Campbell—Hanging pictures
1085 C. Langley—Removing deposit from tubes, flues, &c.
1086 W. W. Hooper—Vehicles
1087 W. E. Newton—Motive power
1088 A. V. Newton—Rotary engines
1089 T. H. Blamires—Indicating votes
1090 W. R. Lake—Paper, &c.
1091 P. Jensen—Pumps

### Dated April 10th 1869.

1092 H. W. Lobb—Velocipede
1093 S. F. Van Choate—Firearms
1094 E. Brasier and J. E. Hodgkin—Scutching or cleaning flax
1095 W. Smith—Looms
1096 H. A. Bonneville—Sewing machines
1097 W. Ashton—Indicating the duty of steam engines
1098 J. Hynam—Crucibles
1099 J. M. Hetherington—Combing cotton
1100 J. B. Spence—Iron and steel
1101 P. Headridge—Dentistry
1102 D. B. Peebles—Gas meters
1103 E. C. C. Stanford—Gaseous matters
1104 G. Haworth, H. Haughton, and R. Gibbons—Consumption of smoke
1105 O. Vivier—Escapements
1106 J. H. Johnson—Removing hair from skins
1107 J. Parry and R. Morris—Saws
1108 E. T. Hughes—Improved stitch
1109 W. Martin—Ships
1110 L. J. Crossley and R. Hanson—Improvements in valves
1111 J. Wadsworth—Lighting fires
1112 D. Johnson—Flour
1113 J. H. Dales and J. F. Maygrove—Looms for weaving hair cloth
1114 A. M. Clark—Pens

### Dated April 12th, 1869.

1115 W. Crombleholme—Registering number of persons entering vehicles, &c.
1116 E. D. Temple—Railway signals
1117 J. Kirk—Cabs, &c.
1118 S. F. Shore—Propelling railway carriages
1119 J. Easton—Drop drills
1120 W. R. Lake—Improved railway
1121 E. Beanes—Brewing
1122 A. d'Azambuja—Felted fabrics

### Dated April 13th, 1869.

1123 H. Browne—Velocipedes
1124 C. D. Abel—Aerial navigation
1125 S. Holman—Velocipedes, &c.
1126 T. F. Cashin—Indicators, &c.
1127 T. B. Burns—Cases for firearms
1128 W. Brock—Slide valves
1129 J. Roberts—Draw plates
1130 C. Turner—Cowls
1131 B. J. B. Mills—Boots and shoes
1132 R. E. Marshall and G. Marshall—Distributing fumigating matter
1133 W. Gillespie—Furnace bars
1134 W. E. Newton—Railroad rails
1135 A. V. Newton—Fan blower
1136 J. H. Johnson—Compound telegraph wire or conductors
1137 F. Erskine—Fire bars
1138 J. H. Johnson—Dental wash
1139 M. Samuelson and C. Eskrett—Combined metallic envelope, &c.
1140 J. Leechman—Steam engines

### Dated April 14th, 1869.

1141 E. Dowling—Pianoforte actions
1142 J. Chandler—Drawing water
1143 P. A. Blake—Explosive compound
1144 A. H. Renton—Joining pipes
1145 W. H. Hacking, T. Hacking, and J. Chambers—Sizing warps
1146 G. Keighley—Velocipedes
1147 J. McLauchlan—Retorts
1148 T. Atkinson and R. Smith—Indicators
1149 J. Whitley and S. J. Peet—Moulds, &c.
1150 B. W. Farey—Steam engines
1151 W. Wright—Treating ores
1152 J. H. Johnson—Burning liquid hydrocarbons
1153 J. G. Jennings—Building blocks
1154 T. White—Nutcrackers
1155 W. Cradwell—Steam boilers
1156 C. T. Swanston—Enabling railway trucks to be drawn by horses
1157 A. M. Clark—India rubber nipples
1158 C. E. Brooman—Burning liquid hydrocarbons
1159 C. E. Brooman—Motive power

### Dated April 15th, 1869.

1169 H. J. Worssam—Lifting casks, &c.
1161 G. Black—Drills
1162 W. H. Buck—Velocipedes
1163 E. Cooper—Waterproof coats
1164 R. Heyworth—Waterclosets
1165 A. W. C. Williams—Bottles, &c.
1166 F. J. Bramwell—Steam engines
1167 J. Vivian—Engines, &c.
1168 A. M. Clark—Compasses
1169 J. H. Johnson—Steam generators
1170 W. J. Cowlman and A. Doe—School desks, tables, &c.
1171 A. K. Rider—Valves

### Dated April 16th, 1869.

1172 F. Mulliner—Carriages
1173 L. Eggert and O. E. Pohl—Vessels of war
1174 F. F. Whitehurst—Mashing grain
1175 R. Legg—Spinning tobacco
1176 W. H. Thick—Sawing machines
1177 S. Harrison—Ventilating sewers, &c.
1178 G. T. Bousfield—Hydrocarbon oils
1179 A. F. Craig—Cutting pasteboard
1180 J. H. Johnson—Firearms, &c.
1181 W. E. Newton—Burners for explosive gases
1182 J. Ives—Velocipede

### Dated April 17th, 1869.

1183 P. Bogler and H. Kayser—Lift for raising, &c.
1184 E. T. Hughes—Rifled firearms
1185 P. Bogler and E. Kayser—Regulating the delivery of tickets at railway stations
1186 F. Knewstub—Printing
1187 H. W. Dee—Bottles
1188 T. Amies—Heating water
1189 J. Willats and A. J. Martin—Advertising
1100 T. Page—Improvements applicable to rail, tramway, etc.

# ALLIBON & MANBRÉ'S PATENT VERTICAL ANNULAR HIGH PRESSURE MARINE & STATIONARY BOILER,

MANUFACTURED BY MESSRS. ALLIBON, NOYES & CO.
ROSHERVILLE IRON WORKS,
NORTHFLEET.

FIG. 2.

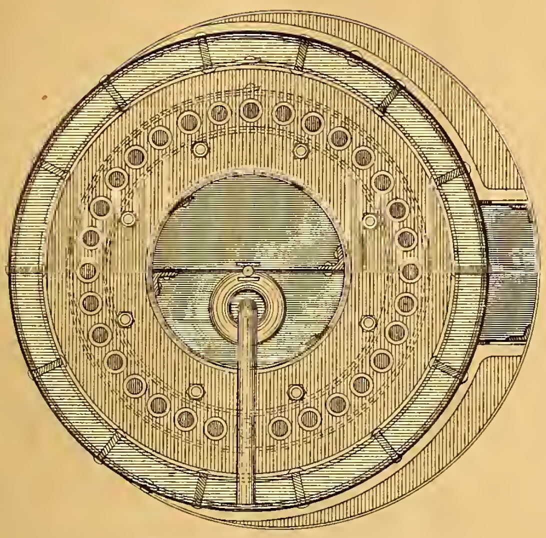


FIG. 4.

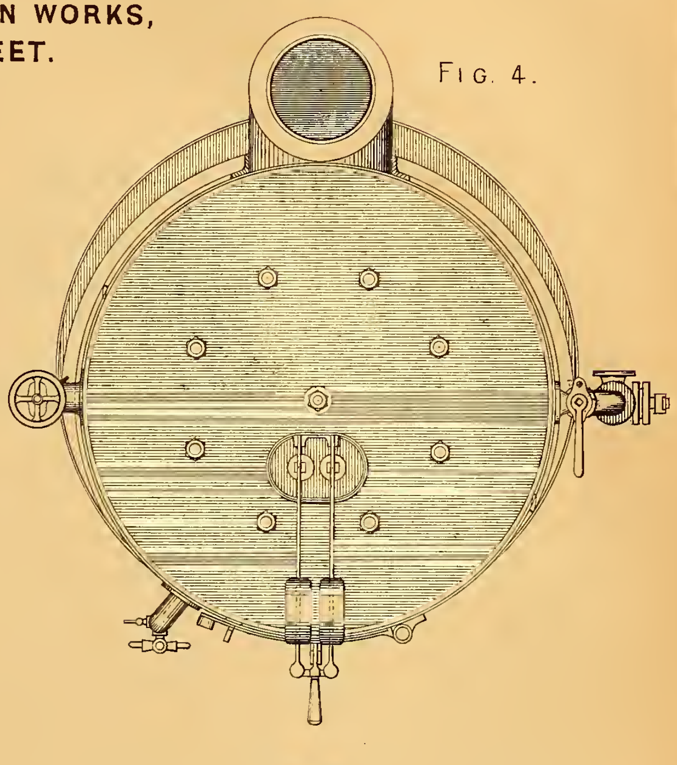


FIG. 1.

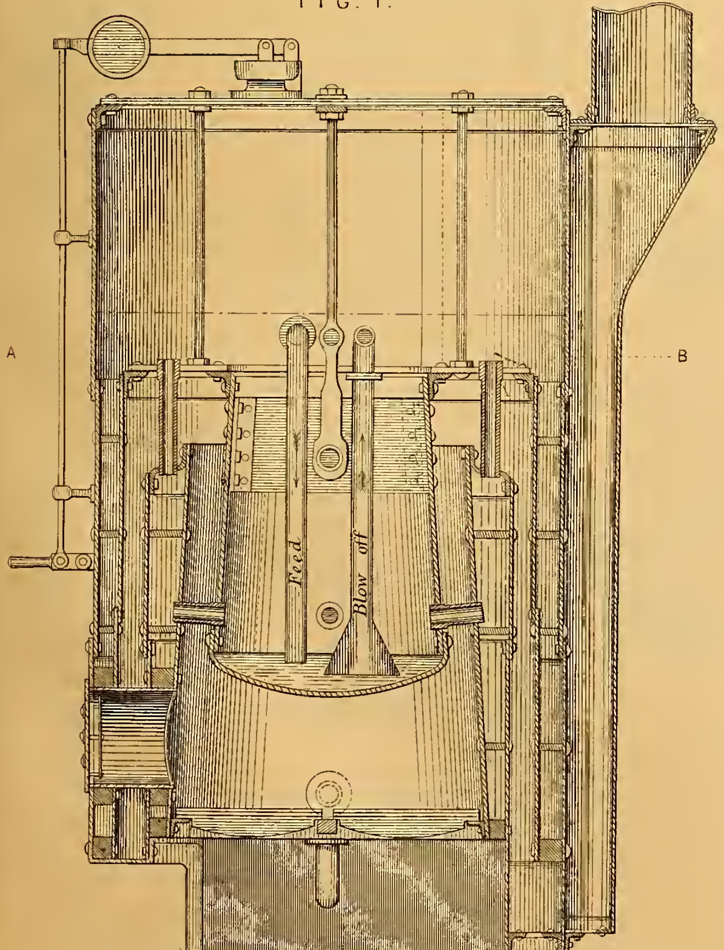
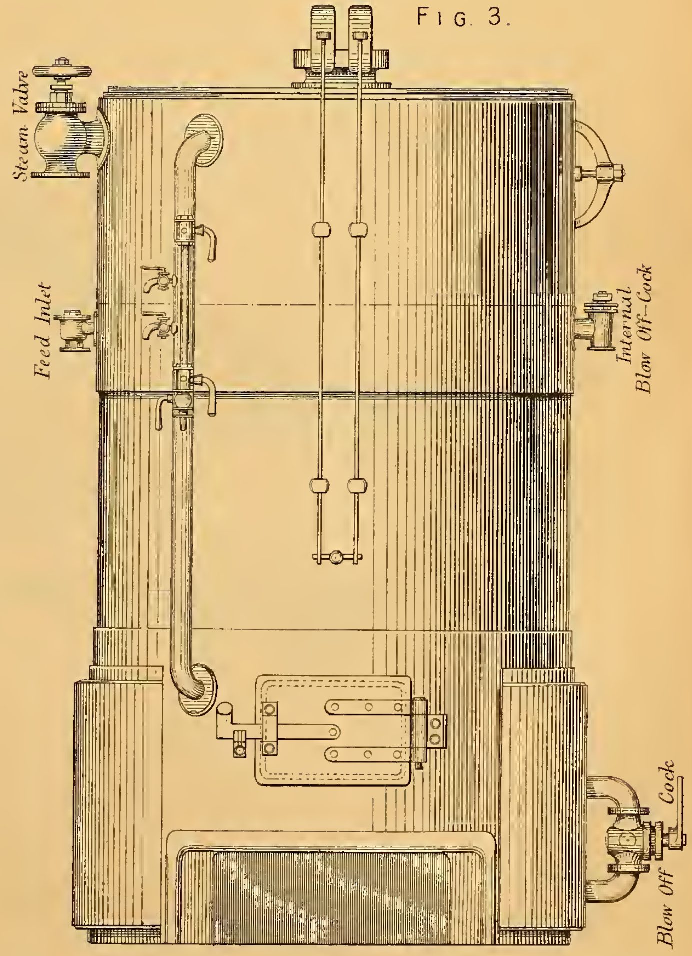
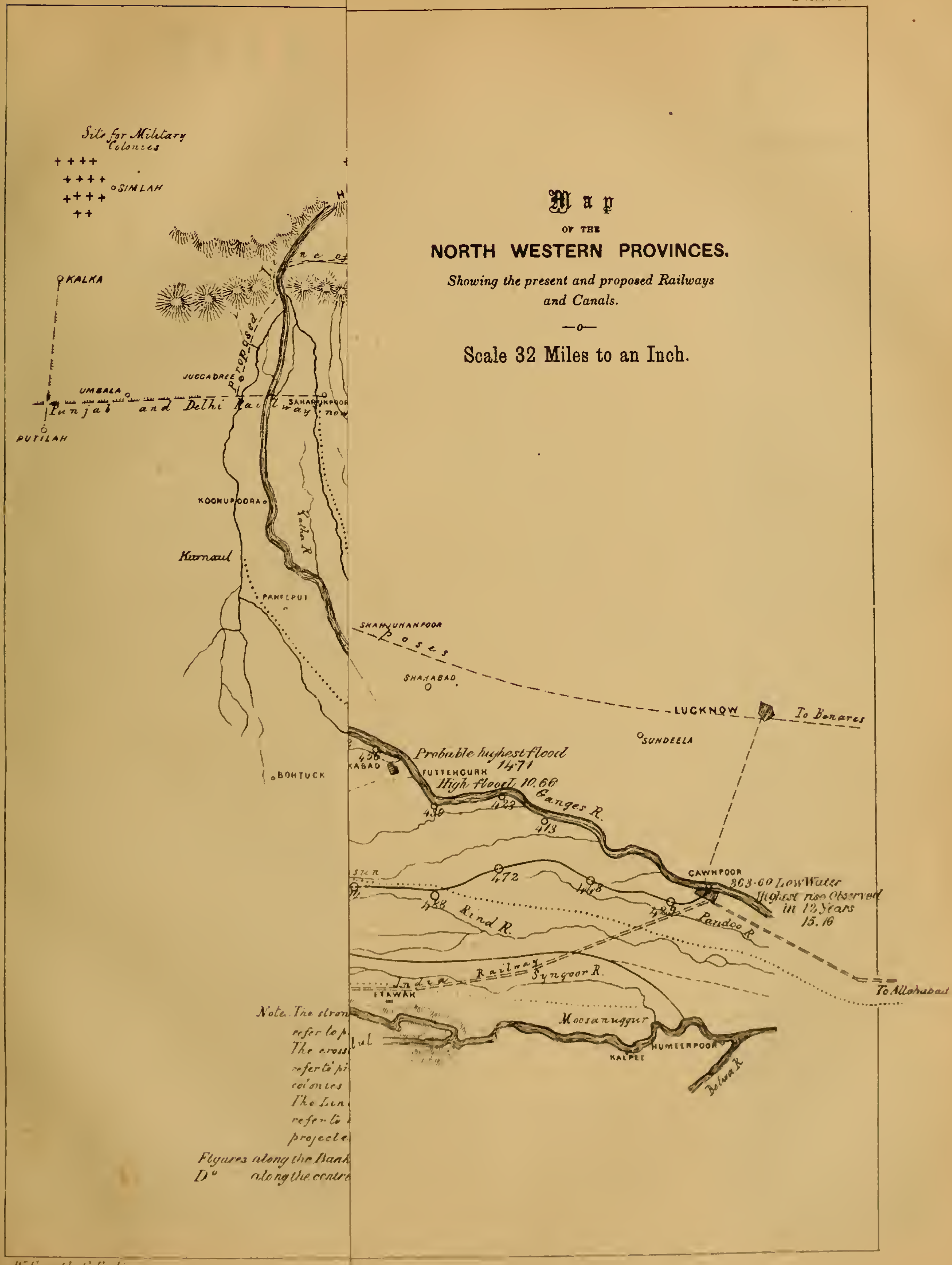


FIG. 3.



*Scale ½ inch = 1 Foot.*

*W. Smith, C.E. direx.*



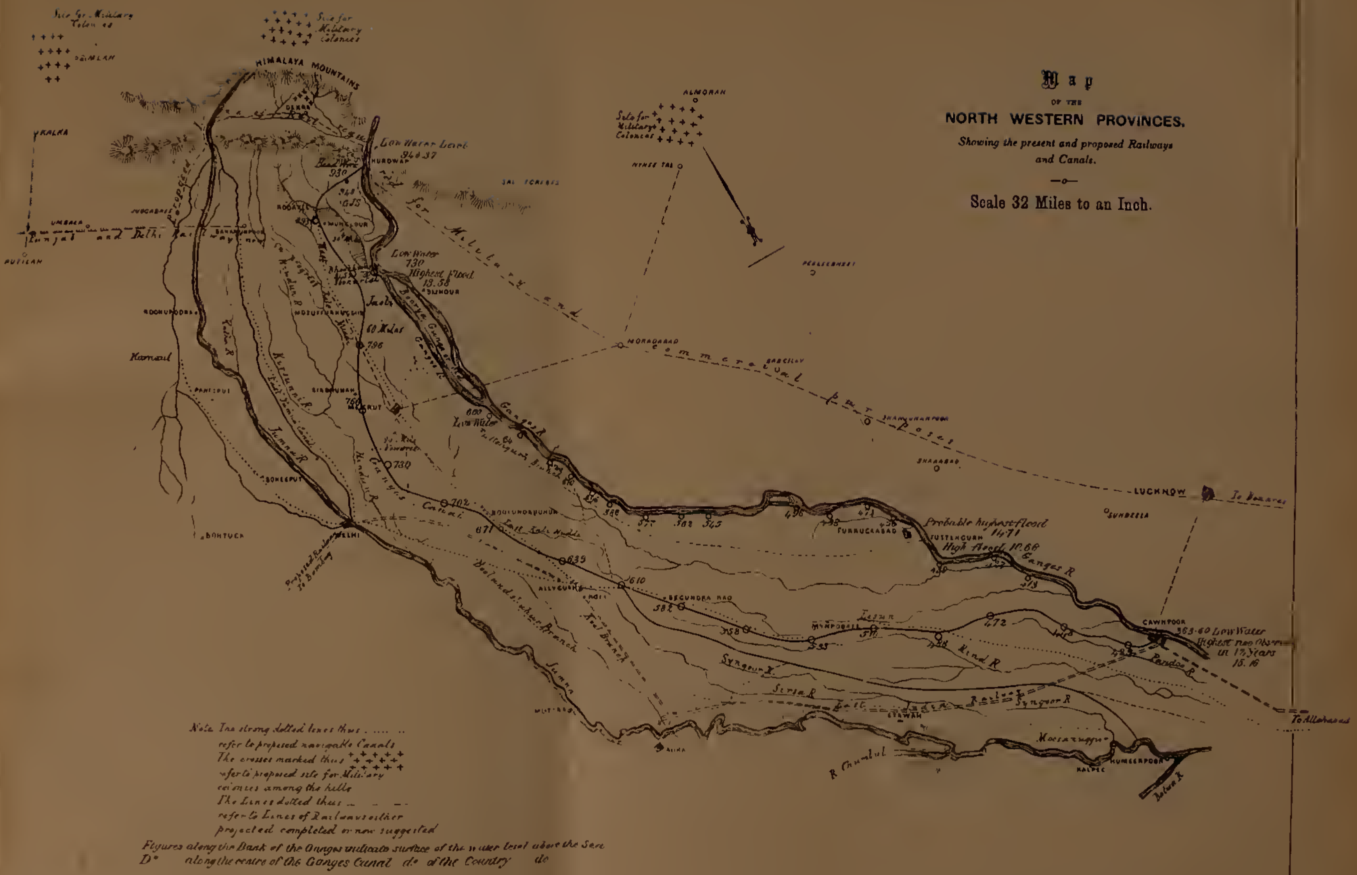
# Map
of the
# NORTH WESTERN PROVINCES.

*Showing the present and proposed Railways and Canals.*

—o—

Scale 32 Miles to an Inch.

W. Smith, C.E. direx



# Map
of the
## NORTH WESTERN PROVINCES.

*Showing the present and proposed Railways and Canals.*

Scale 32 Miles to an Inch.

Note The strong dotted lines thus ..... ..
refer to proposed navigable Canals
The crosses marked thus + + + + +
refer to proposed site for Military
colonies among the hills
The Lines dotted thus — — —
refer to Lines of Railways either
projected completed or now suggested

Figures along the Bank of the Ganges indicate surface of the water level above the Sea
D° along the centre of the Ganges Canal d° of the Country d°

# THE ARTIZAN.

No. 6.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. JUNE, 1869.

## VERTICAL ANNULAR STEAM BOILER.

By Messrs. Allibon & Manbré.

(*Illustrated by Plate* 345).

Within a comparatively recent period, the principles upon which steam boilers are constructed have been considerably modified, and many received opinions that had almost become to be regarded as axioms are now found to have been to a certain extent erroneous. Thus it was always considered that the surfaces acted upon directly by the heat of the furnace should be so formed that any deposit, even when the water was comparatively still, could not find a lodgement; and consequently nearly all the multifarious schemes that have from time to time been proposed, exhibit some arrangement for causing the deposit to settle below the firegrate. It may perhaps be objected that the well-known elephant boiler and the common cylindrical boiler have no such provision, but we do not suppose that any engineer of the present day would adduce either of those forms as examples of safety or economy. At the time when it was considered that the greatest economy was obtained by slow firing, and using boilers containing a large body of water, it was, no doubt, necessary to construct the furnace of such a form that there would be no inducement for the deposit to settle over the crown; but with a boiler containing only a small quantity of water, and with rapid combustion on the firegrate, the contents of the boiler near the furnace are so violently agitated that the deposit is mechanically held in suspension, and it is only when it arrives at a comparatively cool part of the boiler that it settles. This is strikingly illustrated in that class of boilers in which water tubes run down direct from the crown of the furnace to within a short distance of the fire. At first sight it would be imagined that the lower ends having no outlet would be quickly choked with deposit, but experience has in numerous instances proved that so far from this being the case, they keep remarkably clean.

We have been led to the above remarks from having recently inspected at the Rosherville Iron Works, Northfleet, a marine boiler, constructed by Messrs. Allibon, Noyes and Co , from a design patented by Messrs. Allibon and Manbré, which appears to embody many excellent qualities, and which is illustrated in Plate 345. Fig. 1 is a vertical sectional elevation; fig. 2 a sectional plan taken on the line A.B. fig. 1; fig. 3 a front elevation shewing mountings, &c., and fig. 4 a plan of the boiler. It will be seen from these illustrations that the body of the boiler and the fire-box are constructed separately as two distinct parts. The outer part consists of the external skin or shell of the boiler, and a concentric inner cylinder rivetted thereto near to the bottom; a wrought iron ring being interposed to keep them the proper distance apart. This inner cylinder is also firmly stayed to the shell by screwed stays placed 12in. apart. To the top of this inner cylinder a tube plate is rivetted which is also connected to a central conical shaped vessel or pocket; which descends to within about 15in. of the furnace bars. The fire-box consists of two rings forming an annular water space round the furnace; the inner ring being made slightly conical to give a better heating surface, and at the same time to permit the steam to get away freely. The top of this fire-box is connected to the tube plate by means of short, lap welded tapered tubes which are screwed at both ends, the screw in the top plate being of sufficient size to allow the tube to pass through. Tubes are also fitted between the lower part of the pocket, and the annular water space round the fire-box for the purpose of permitting the circulation of the water between them. The products of combustion after playing round the central pocket pass up to the top of the fire-box, when they are deflected by the upper tube plate and descend between the outer plate of the fire-box, and the inner cylinder or body of the boiler until they arrive at the bottom, where they pass into an annular flue surrounding the base of the boiler, with which an oblong flue or up-take communicates with the chimney.

Messrs. Allibon and Manbré claim for the new boiler advantages which, being realised in practice, must tend strongly to bring vertical boilers more generally into favour; thus, amongst the more important features we may mention the ensuring a thorough circulation of the water, and the rapid boiling off of large volumes of steam; combined with the thorough utilisation of the products of combustion, simplicity in the construction of the different parts, and great strength of the whole as a steam generator. It might perhaps be thought that the lower portion of the pocket would be liable to an accumulation of deposit, but in practice such is not the case; the violent ebulition, as was pointed out in the former part of this article, holding in mechanical suspension all impurities until they find a quieter resting place in that portion of the annular ring which is below the firegrate. As an additional precaution a blow off pipe is placed in this pocket as shown in fig. 1, although in practice it is found to be almost superfluous.

The boiler illustrated in Plate 345 is of 20 horse power, the area of firegrate being 9 square feet, and the effective heating surface 212 square feet, and the steam pressure at which it is intended to work 60lbs. per square inch.

The advantages of the vertical, self contained class of boilers in the saving of space, facility of erection &c. is well-known. A really safe and efficient upright boiler is consequently a great desideratum, and so far as we can judge, the boiler invented by Messrs. Allibon and Manbré possesses both these qualifications.

## ROADS, RAILWAYS, AND CANALS IN INDIA.

(*Illustrated by Plate* 346).

In a pamphlet on the above subject, published by Messrs. Spon, the writer—Mr. T. Login—has made many practically useful suggestions in connection therewith, and we intend from time to time to make extracts therefrom, which will be found of great value to the engineers, both young and old, in India. We give, with the present issue, a map of the N.W provinces of India, showing the railways completed and projected, as well as the irrigation canals from the Ganges and the Jumna rivers. The lines of navigable canals suggested by Mr. Login are also indicated, and, as there has long been, and even now is, great diversity of opinion as to the policy and commercial advantages of constructing canals in Northern India, to enable our readers to form a correct judgment on this important question, we have added the levels above the sea of the surface of waterway of the Ganges, and the surface of the country along the line of the Ganges Canal, about which we shall very shortly have something to say, as enormous sums of money are about to be raised for the construction of public works in India; how important it is that the money should not be squandered or blundered away, those who will have to provide it must be made to fully understand. Mr. Login writing upon roads, their constitution and maintenance, states:—"Portions of the Grand Trunk Road are now actually costing more to keep in repair than a line of railway; the latter being about 100 rupees a month a mile, while portions of the Grand Trunk Road are costing upwards of 120 rupees a month a mile. With such an enormous expenditure, therefore, increasing year after year, a time must soon be reached when all the available money will be swallowed up in repairs, unless more funds be supplied by local taxation, or some other means be devised for facilitating the traffic, which is daily increasing.*

The only way, therefore, that appears to meet the difficulty is to have navigable canals. The chief cost of these works will be the first outlay; but after that, the maintenance will be, comparatively speaking, little beyond the loss of a little water by evaporation and absorption; but as the velocity will be slight, the bed can be puddled, and thus the leakage reduced to a minimum.

Supposing that the loss of water by absorption and evaporation, including lockage at the lower extremity of a canal, is in all 1½ft. a second per mile, and that it will require 500 miles of navigable canal to connect Roorkee, Saharunpore, Kurnal and Delhi with Allahabad. Also that 100 yards average breadth of land is required for the canals, and that an acre of land is worth Rs. 40, while a cubic foot of water per second is worth Rs. 400 a year.

We have 500 × 1½ × 400 = Rs. 300,000, and one square mile of land required for every 17·6 miles of canal or $\frac{500}{17{\cdot}6} = 28$ square miles. Then $\frac{28 \times 640 \text{ acres} \times 40 \text{ rupees}}{20 \text{ years' purchase.}} =$ Rs. 36,360; or, in rough numbers, the expenditure of land and water would equal Rs. 350,000; about the present expenditure on two divisions of the Grand Trunk Road, independent of the expenditure from the local funds on the maintenance of roads. Now, if the navigable canals would relieve the roads of one half of the traffic, it appears that were water communication adopted, the saving of wear on the Imperial roads alone would almost cover the compensation for land and loss of water. Therefore, if Government gave the land and the water for nothing to a private company, with the *present traffic*, Government would be no loser.

These canals should run through the centres of the chief cities, and the full 100 yards in width should be taken up, the Company paying the compensation for all buildings, &c. This, though a great outlay at first, would ultimately pay well; for supposing 100ft. to be required for the canal, 100ft. for road, 50ft. broad on either side, there would still remain 100ft. also for building sites, the rents for which would fully pay for the compensation.

The surface level of the water should be at least 1ft. *above* the roads, so that there could be no drainage *into* the canal, thus there would be always a flow of clean water through our chief cities. With an open space 200ft. wide through every town, a flow of clean water, with the merchandize brought up to the door of every shopkeeper, not to speak of the water power available at every lock, it is difficult to imagine how much the country would be benefited, without putting Government to any extra expense, while the projectors of such works would find it highly remunerative.

Judging from Major Crofton's estimates, the probable cost per mile for a 50ft. broad navigable canal should not exceed Rs. 20,000

To this add compensation, management, &c., 10,000

Total, 30,000

or 500 miles of navigable canals may be constructed through the richest portion of India to connect its chief cities, at a cost of not more than one and a half million pounds sterling.

Taking the average slope of the Doab at 17in. in the mile, and that of the canal only 6in., 11in. have to be got over by locks in every mile, or in all say 450ft. and taking the discharge at 250 cubic feet a second passing, through these locks, we have (see Beardmore's Hydraulics) water power per foot of fall, as follows:—

| | Horse power. |
|---|---|
| Undershot wheel ... ... ... ... | 9·9 × 450 = 4,455. |
| Breast ... ... ... ... ... ... | 15·6 × 450 = 7,020. |
| Turbine ... ... ... ... ... ... | 21·3 × 450 = 9,585. |

Or an average of 7,020 horse-power.

Supposing only one-half of the power be made use of, we have distributed over the country 3,500 horse-power, available for sugar, oil and grain mills, &c., &c.; and taking each horse-power at the low rate of 8 annas in the 24 hours, we have at once a return of 4 per cent. on the total outlay from this source alone, independent of navigation. Now, as it is found that it is better to run the risk of rafting down sál timber from the forests at the foot of the hills on the left bank of the Ganges to Cawnpore, and then to pull it up against the stream of the Ganges Canal to near Meerut, than to cart it by the direct road, some slight idea may be formed, without going into figures, of the difference of cost between land and water transport.*

*Return showing cost of Transport of* 100 *Maunds weight of Goods one mile*

| Mode of Transport. | Rate. | | | Probable distance travelled daily. | Remarks.† |
|---|---|---|---|---|---|
| | RS. | A. | P. | | |
| | | | | Miles. | 1 md. = 80lbs. |
| Ocean long voyages ........... | 0 | 0 | 2·20 | 150 | Obtained from report of State Engineer of New York for 1853. |
| American lakes ................. | 0 | 0 | 4·76 | ... | |
| Hudson river .................... | 0 | 0 | 4·00 | ... | |
| Erie canals.......................... | 0 | 0 | 6·35 | ... | |
| Ordinary canals ................. | 0 | 0 | 8·00 | ... | |
| Coal railways ..................... | 0 | 0 | 11·00 | 80 | |
| Favourable passenger lines ... | 0 | 1 | 8·00 | 150 | |
| Passenger lines, steep gradients | 0 | 2 | 8·25 | 150 | |
| East India Railway, lowest rate | 0 | 2 | 1·00 | 150 | Indian rates of transport for grains and the cheapest description of goods. |
| Country carts, over metalled roads ............................ | 0 | 4 | 0 | 12 | |
| „ „ country road | 0 | 5 | 4·00 | 12 | |
| Indian Carrying Company over the Grand Trunk Road ...... | 0 | 6 | 11·00 | 33⅓ | |
| Probable rate by Navigable Canals in Upper India ...... | 0 | 1 | 0 | 12 | |

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* In addition to this annual outlay of nearly £150 a-year per mile on Maintenance, there is the share of Superintending, Chief Engineer and Controller of Account's Offices; again there are police along the line, which, charging all that is debitable to them, altogether cost £40 more per mile. From this sum £15 may be deducted, for those on duty not connected with the road. Therefore, the maintenance in all costs little under *two thousand rupees per mile yearly*, or two hundred pounds sterling, *without any returns in the shape of tolls*; while the outlay by the Commissariat at Umhallah for the transport of beer and tea *alone* from Delhi costs £5,000 a-year or upwards of £40 a mile more.

* The charge for the conveyance of goods by the Inland Transit Company along the Grand Trunk Road, for a distance of less than 80 miles, is greater than the freight from London to Calcutta.

† Since the above table was prepared, by Notification No. 4,570. of 22nd October, 1866, published in Punjaub Government Gazette, No. 44, of 1st November, 1866, the hire of bullock carts has been considerably increased, and the loads reduced as calculated in the above table, raising the rates to Rs. 0-11-8 per 100 maunds per mile, over metalled roads; and Rs. 0-14-7 per 100 maunds, over country roads, where the marches equal on average 12 miles.

The rates are 7 annas a day for one bullock, and the load on metalled roads is only 5 maunds per bullock, and 4 maunds on country roads, from which we obtain as follows:—Over metalled roads, one bullock's load is $\frac{5}{100}$ or $\frac{1}{20}$ of 100 maunds, or the carriage would be for 12 miles 7 annas × 20 = 140, and $\frac{140}{12} =$ Rs. 0-11-8 per 100 maunds a mile; and over country roads, one bullock's load is $\frac{4}{100} = \frac{1}{25}$ for 12 miles, and 7 × 25 = 175 annas, and $\frac{175}{12} =$ Rs. 0-14-7 per 100 maunds a mile. Where there is steady employment and the distances are long, the rate, though no doubt increased since the late order, may still be taken on an average at half the above, or Rs. 0-5-10 on metalled roads, and Rs. 0-7-3½ over country roads. (See rates for carriage of kunkur on the 7th Division, G. T. Road published in Supplement of Punjaub Government Gazette, dated 7th March 1867).

The probable rate of interest to be charged on goods would be one anna per 100 rupees daily, or 22½ per cent. nearly (22·8 per cent.) Therefore the cost of transport of 100 maunds of grain, worth 100 rupees at prime cost, conveyed by canals a distance of 300 miles, would be—

| | R. | A. | P. |
|---|---|---|---|
| Cost of carriage of 100 maunds $\frac{100}{16}$ …………… = | 18 | 12 | 0 |
| Time of transport, 25 days at Rs. 0-1-0 ………… = | 1 | 9 | 0 |
| Total…… | 20 | 5 | 0 |

or nearly 20 per cent. on prime cost.

Should the rate be reduced to 8 pie a mile

| | | | |
|---|---|---|---|
| The cost of carriage of 100 mds. = $\frac{300 \times 8}{12 \times 16}$ … = | 12 | 8 | 0 |
| Time of transport, 25 days, at Rs. 0-1-0 ……… = | 1 | 9 | 0 |
| Total…… | 14 | 1 | 0 |

or only 14 per cent. on prime cost.

By the lowest rate of railway charges,

| | | | |
|---|---|---|---|
| The cost would be 300, at Rs. 0-2-1 …………… = | 39 | 1 | 0 |
| Add time of transport, 2 days…………………… = | 0 | 2 | 0 |
| Total…… | 39 | 3 | 0 |

or 39 per cent. on prime cost.

By country carts, on metalled roads,

| | | | |
|---|---|---|---|
| The cost would be 300, at Rs. 0-4-0 ………… = | 75 | 0 | 0 |
| Add time of transport, 25 days………………… = | 1 | 9 | 0 |
| Total…… | 76 | 9 | 0 |

or 76·72 per cent. on prime cost.

By country carts, on unmetalled roads,

| | | | |
|---|---|---|---|
| The cost would be 300, at Rs. 0-5-4 ………… = | 100 | 0 | 0 |
| Add time of transport, 25 days………………… = | 1 | 9 | 0 |
| Total…… | 101 | 9 | 0 |

or over cent. per cent. on prime cost, with no allowance made for back hire,

By bullock train over the Grand Trunk Road,

| | | | |
|---|---|---|---|
| The cost would be 300, at Rs. 0-6-11…………… = | 114 | 3 | 6 |
| Add time for transport, 9 days, at Rs. 0-1-0 … = | 0 | 9 | 0 |
| | 114 | 12 | 6 |

or nearly 115 per cent. over prime cost for the cheapest class of goods, and 100 per cent. over the lowest rate by canals.

Comparing the cost by railway and by canal, if the rate is one anna a mile, it is only one-half the railway rate nearly, and about one-third the railway rate if the charges be only 8 pie. Therefore, till the interest on the capital of prime cost makes up the difference owing to the loss of time by the canal, water transport would be preferred to railway carriage. That is, no goods would be sent by railway under ordinary circumstances that cost less than 14 rupees a maund, or £39 4s. per ton, for

| | R. | A. | P. |
|---|---|---|---|
| 100 maunds transported 300 miles, @ Rs. 0-1-0 ……… = | 18 | 12 | 0 |
| Interest on 100 maunds, @ Rs. 14 for 25 days, @ Rs. 0-1-0 per cent. ……………………………… = | 21 | 14 | 0 |
| | 40 | 10 | 0 |
| And 100 maunds for 300 miles, @ Rs. 0-2-1…………… = | 39 | 1 | 0 |
| Interest on 100 maunds, @ Rs. 14 for 2 days, @ Rs. 0-1-0 per cent. ……………………………… = | 1 | 12 | 0 |
| | 40 | 13 | 0 |

Again—Suppose one European soldier costs the state £100 a year or Rs. 2-11-10 daily, and that he can be conveyed by rail 1,000 miles for Rs. 16 in three days, the cost to Government would be—

| | | | |
|---|---|---|---|
| Rs. 2-11-10 × 3 ……………… = | 8 | 3 | 6 |
| Add railway charge ………… = | 16 | 0 | 0 |
| Total …… | 24 | 3 | 6 |

To march 1,000 miles at the rate of 12 miles a day, without halts, would occupy 83 days, and Rs. 2-11-10 × 83 = Rs. 227-6-4; or by a quick railway he can be carried at nearly one-tenth the cost to Government than if he had to march, and his services are available 80 days sooner. The natural conclusion to be arrived at therefore is, that both quick railways and slow navigable canals, are required for the protection and development of India.

(*To be continued.*)

## SEA-GOING TURRET SHIPS.

By Admiral Paris, C.B.

(*Concluded from p. 99.*)

In the following tables will be found all that is necessary to form a general idea of the vessels when supplemented by the various figures shown in the Plate (343).

*Dimensions and results of Calculations for the Three Designs.*

| | Design No. 1. | Design No. 2. | Design No. 3. |
|---|---|---|---|
| Length of vessel at water line………………… | 93·6m. | 88·30 m. | 68·50m. |
| Breadth (outside) ……………………………… | 22 | 18 | 15·50 |
| Proportion of breadth of length ……………… | 1 to 4·25 | 1 to 4·64 | 1 to 4·3 |
| Breadth of "inner vessel" …………………… | 13·80m. | 9·60m. | 9m. |
| Proportion of inside to outside breadths …… | 1 to 1·594 | 1 to 1·968 | 1 to 1·72 |
| Outside diameter of turrets ………………… | 8·50m. | 8m. | 8m. |
| Draught (estimated) ………………………… | 6·75 | 5·75 | 5 |
| Do. with extra amount of coal ………… | 7·20 | 6·10 | 5 |
| Displacement in tons…………………………… | 8,368 | 6,129 | 3,202 |
| Midship section in square metres……………… | 126 | 92 | 66 |
| Area at water line do. ……………… | 1,552 | 1,264 | 800·78 |
| Displacement for 1 centimètre………………… | 15·88 tons | 12·96 tons | 8·20 tons. |
| Distance of centre of *carène* to water line…… | 2·875m. | 2·470m. | 2·10m. |
| Do. do. from bottom of vessel | 3·875 | 3·280 | 2·90 |
| Height (above water line) of metacentre …… | 3·00 | 2·80 | 2·05 |
| Do. do. upper deck ……… | 5·30 | 3·7 | 3·10 |
| Do. do. top of gunwale …… | 6·9 | 5·80 | 4·60 |
| Do. do. port sill of battery | 3·00 | | |
| Do. do. in turrets………… | 6·10 | 4·60 | ·0 |
| Do. do. watch deck ……… | 7·70 | 5·50 | ·80 |
| Do. do. nettings ………… | 9·30 | 6·50 | ·10 |
| Do. do. top of turrets …… | 7·90 | 6·90 | 5·90 |

*Particulars of Armour Plating.*

| VERTICAL PLATING. | Design No. 1. | Design No. 2. | Design No. 3. |
|---|---|---|---|
| Thickness of plating ……………………………… | 0·20m. | 0·20m. | 0·15m. |
| Length of do. (both sides)………………………… | 198 | 183·00 | 141 |
| Height of do. above water level ……………… | 1·00 | 0·80 | 0·60 |
| Do. below do. ……………… | 1·70 | 1·75 | 1·50 |
| Total width ……………………………………… | 2·70 | 2·55 | 2·10 |
| Area of do. ……………………………………… | 534 | 468 | 302·8 |
| Ratio of area above and below water line …… | 1 to 1·7 | 1 to 2·08 | 1 to 2·5 |
| Total weight……………………………………… | 833 tons | 278 tons | 350 tons |
| Number of turrets ……………………………… | 2 | 2 | 1 |
| Length of central battery……………………… | 87m. | 39m. | 18·50m. |
| Height of do. …………………………………… | 3·90 | 2·30 | 2·2 |
| Area of do. ……………………………………… | 339 sq. m. | 91 sq. m. | 40·7 sq. m. |
| Thickness of plates of do.……………………… | 0·20 | 0·25 | 0·25 |
| Weight of do. …………………………………… | 527 tons | 176 tons | 78 tons |
| Total area of turrets…………………………… | 159 sq. m. | 151 sq. m. | 75·5 sq. m. |
| Weight of lower ring 1m. high and plates ·3m. thick ……………………………………… | 124 tons. | 116 tons | 58 tons |
| Weight of upper part, ·25m. thick …………… | 197 | 194 | 97 |
| Total weight of turrets ………………………… | 321 | 310 | 155 |
| Area of vertical surface of wheel house ……… | 15 sq. m. | 5·6 sq. m. | 3·9 sq. m. |

| VERTICAL PLATING—(*contd.*). | Design No. 1. | Design No. 2. | Design No. 3. |
|---|---|---|---|
| Weight of do. | 24 tons | 8·7 tons | 3 tons |
| Total of vertical surfaces | 1037 sq. m. | 716 sq. m. | 439 sq. m. |
| Weight of do. of ·2m. thick | 1687 tons | 1116 tons | |
| True weight of do. as adopted | 1724 | 1223 | 592 tons |
| HORIZONTAL PLATING. | | | |
| Thickness of plating on outer deck | 0·05m. | 0·05 | 0·04m. |
| Area of do. | 476 sq. m. | 512 sq. m. | 267 sq. m. |
| Weight of do. (¼ thickness of vertical plates) | 185 tons | 199 tons | 83 tons |
| Thickness of plating on inner deck and hatchways | 0·04m. | 0·04m. | 0·03m. |
| Area of do. (deducting turrets) | 617 sq. m. | 745 sq. m. | 431 sq. m. |
| Weight of do. (⅕ thickness of vertical plates) | 192 tons | 232 tons | 101 tons |
| Total horizontal surface | 1093 sq. m. | 1257 sq. m. | |
| Total wght. of do. at their respective thicknesses | 377 tons | 431 tons | 184 tons |
| Total weight of plating of vessel | 2101 tons | 1654 tons | 776 tons |
| RATIOS, &c. | | | |
| Nominal horse-power of engines | 1200 | 900 | 400 |
| do. per sq. metre of midship section | 9·52 | 9·67 | 5·42 |
| Number of guns capable of firing on one side | 7 | 4 | 2 |
| Area of plated surface for one gun | 182 | 246 | 299 |
| Weight do. do. | 300 | 410 | 388 |
| Displacement of vessel do. | 1166 | 1446 | 1601 |
| Nominal horse-power do. | 171 | 222 | 200 |
| Number of guns (protected), capable of firing in line with keel forward | 2 | 2 | 2 |
| Do. do. aft. | 2 | 2 | 2 |
| ESTIMATED WEIGHTS. | | | |
| Hull complete | 2620 | 1750 | 980 |
| Backing of armour plates | 680 | 530 | 250 |
| Total (hull and backing) | 3300 | 2280 | 1230 |
| Armour plate, bolts, &c. | 2160 | 1660 | 870 |
| Masts, rigging, and fittings | 380 | 250 | 118 |
| Ship's company and stores | 170 | 100 | 60 |
| Guns and ammunition | 420 | 210 | 120 |
| Engines and boilers in working order | 1100 | 800 | 400 |
| Coal | 800 | 800 | 280 |
| Total | 8330 | 6100 | 3078 |

These last estimates of weights have been calculated by the naval architect of the dockyard of the Forges et Chantiors de la Méditerranean, near Toulon, who is the well-known builder of the *Numancia*, *Maria Pia*, *San Martino*, *Brazil*, &c. The *Numancia*, which was built for the Spanish Government, was the first iron-clad which made a voyage round the world, and her performance at sea has been highly praised by all on board. Allowing for the experience gained since that time, the calculations of such a thoroughly practical shipbuilder, may be confidently relied upon; he also estimates the speed of the designs, No. 1 and 2, at 14½ knots, and that of No. 3 at 12½ knots. According to the schedule of prices adopted by the Forges et Chantier de la Méditerranean, viz., 1·38 francs per kilogramme for vessel and furniture, the cost of No. 1 design would be 8,060,000 francs; that of design No. 2, 5,782,000 francs, and that of the third design 3,060,000 francs; and calculating for the engines a sum of 1,360 francs per nominal H.P., the cost would be 1,500,000, 1,088,000, and 540,000 francs respectively.

## PATENT LAW.

### The Bovill Litigation.

(*Continued from page* 106.)

When the case came before the full Court of Queen's Bench, it was elaborately argued upon the points reserved at the trial, and upon the ground that the verdict was against the evidence. As stated in the Law Reports, one of the points insisted upon for the defendants seems an odd one. It was that if the specification intended to claim the use of the combination of the blast and exhaust only when worked with a fixed top-stone, then there had been no infringement; but if it intended to claim the use of that combination whether the top-stone was fixed or running, the patent was invalid, as such a claim was too wide, since some sorts of blast, when worked in combination with some kinds of exhaust, might not be advantageous, and yet every sort of combination was claimed as patented.

We give the judgment verbatim:—

"Lord Campbell, C.J.: We are of opinion that the objections to the validity of this patent cannot be supported. The whole of the plaintiff's process, if the combination be new, is certainly the subject of a patent; and so would the parts, No. 2, if taken separately, for 'exhausting the air from the cases of mill-stones, combined with the application of a blast to the grinding surfaces,' as they introduce very important 'improvements in manufacturing wheat and other grain into meal and flour.' The combination of the exhaust with the blast, so as to carry off the warm dusty air blown through between the stones to a chamber above, while the pure flour, in a dry condition, without the stive descends into a chamber below, added to the quantity and improved the quality of the flour produced in grinding; and its effect was highly favourable to the health and comfort of the men employed in the operation.

"Still, if the specification does not point out the mode by which this part of the process (No. 2) is to be conducted, so as to accomplish the object in view, it would be the statement of a principle only, and the patent would be invalid. But we are of opinion that the specification, on the face of it, cannot (as contended) be pronounced, in point of law, to be bad in this respect; and we are of opinion that the evidence adduced at the trial shows it to be quite sufficient. The specification says: 'In carrying out the second part of my invention when working mill-stones with a blast of air, I introduced a pipe to the mill-stone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber, as hereafter described.' 'And this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the mill-stones without a blast.' The exhaust produced by the pipe and fan is to be proportioned to the plenum caused by the blast, taking care not to produce the inconvenient current of air, against which a caution is given. How can a Judge take upon himself to say that this may not be enough to enable a workman of competent skill to construct the machinery? According to the evidence, the specification was abundantly sufficient for this purpose; and therefore it could be no more necessary in the specification to explain the details, by which the pipe and fan were to be employed to create and to regulate the exhaust than to describe how the mill-stone case or the stones themselves were to be fashioned. The learned counsel for the defendants, after being familiarly acquainted with the manner in which this part of the process is conducted, being asked to suggest the fit language to be employed to instruct the workman how to adjust the exhaust so as properly to suck away the plenum, that the stive may be discharged into the chamber above, were unable to devise any improvement upon the specification.

"Therefore, the plaintiff being now allowed to be the inventor, the jury being in our opinion fully justified in finding that the process had not been publicly practised at Glasgow before the date of the patent, and the specification being sufficient, the patent is valid; and we have only to consider whether there has been an actionable infringement of it by the defendants using the exhaust and the blast in the manner described (No. 2), in a mill in which the upper stone rotated and the nether stone was fixed.

"The plaintiff contends that his patent, as explained by the specification, was originally for four separate and independent inventions, and that No. 2 in the amended specification must be considered a separate and independent invention, as if the patent had been granted for this alone. The defendants contend, on the contrary, that the patent was granted for one process comprising several successive and connected parts, the use of fixed upper millstones being one of them. We do not think it necessary to try to reconcile the different parts of the specification (which are sometimes conflicting), or to give any positive opinion upon this question; for, supposing the patent to be for a combination, consisting of several parts for one process, we are of opinion that the defendants are liable in this action for having used a material part of the process which was new for the same purpose as that mentioned in the specification, although they did not at the same time use all the parts of the process as specified. The defendants admit that they used the parts of the process No. 2, as described in

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the amended specification; and they rest their defence upon the fact that they did so only in a mill with a rotating upper mill-stone. But if the fixed upper mill-stone were clearly described by the plaintiff, in the statement and diagram to be found in his specification, as part of the combination for which he took out his patent, as No. 2 is a material part of the combination, and was new, we are of opinion that they cannot lawfully use No. 2 for the same purpose, by substituting a rotating upper mill-stone for a fixed upper mill-stone, or by resorting to any other equivalent for any other separate part of the process specified. This case seems to us governed by Lister *v.* Leather, and the authorities which in that case we fully commented upon, and, therefore, that there ought to be judgment for the plaintiff."

This judgment must excite amusement and perplexity when attentively considered. It presents the Lord Chief Justice of England and his grave and reverend colleagues disposing of the merits of the case at a time when they had not satisfied themselves of the meaning of the document upon which those merits depend. Before determining the construction of the specification, they decided that it was not open to the objections urged against it, and that the patent was valid. Their patience in having a second argument of the question, whether there could be an infringement in a mill where the top-stone was a runner, was, in a certain sense, admirable. We venture to say that no engineer ever entertained any doubt that the specification did not intend to confine the second claim to be used only with a fixed top-stone; and that if the question had been before a properly constituted tribunal for patent causes, the previous point would have been first settled. What was the reason why the limitations to be found in the specification were introduced? Were they to indicate the most advantageous or the only modes of working the improvements invented? or were they mere alterations of detail to enable the patentee to claim old improvements under new circumstances? This was the previous point; and when it was settled, there could have been no difficulty in answering the question, whether the invention had been used or the patent infringed. The case ended in a mere jumble of words. If it was ever argued that all the claims of the specification contained one entire combination, it could surely never have been attempted to realise what that combination would have looked like in actual fact. The claim for fixing the top-stone, and causing currents of air by exhaustion or pressure to pass through the grinding surfaces of mill-stones when the top-stone is fixed, is obviously not designed to be a part of the same combination with the exhaust from the cases of mill-stones in combination with the application of a blast to the grinding surfaces of the stones. Three distinct modes of working are indicated:—1st, When you have a fixed top-stone use the blast to ventilate the grinding surfaces; 2nd, under the same circumstances use the exhaust for the same purpose; 3rd. whether the top-stone is fixed or running use the exhaust to carry off the stive when you use a blast to ventilate the grinding surfaces. The reasons assigned in the specification make it manifest that the intention of the patentee was to describe, not a series of improvements, all of which were to be used together, but to enumerate all the circumstances under which he claimed the monopoly of an improvement which had previously been in use, but under other circumstances. He admits that, with a running top-stone, the blast and also the exhaust had been used to ventilate the grinding surfaces, but they had never before been used together, nor had either of them before been applied when the top-stone was fixed. Such considerations as these do not seem to have weighed with the Court. These deal with the substance of the invention and the reason of the thing. In trying a patent cause, it would have been supposed that each claim would have been considered, and the question asked, what new invention and substantive improvement is represented by it? In this judgment we see no trace of this as to the first claim or the third claim. By disregarding this method, the Court entered a fool's paradise, and lost itself in a grammatical inquiry which had not the slightest reference to the substantial merits of the question between the parties; and at length it emerged from this maze, stating it really did not matter what the patentee intended. There was a rule of law by which the defendants could be made to be infringers whether they had or had not used that particular improvement of which Mr. Bovill was the inventor.

But there are other parts of this judgment which must be remarked upon. We must defer to the learned judges in all matters of law, but in reference to the meaning of a specification we claim the right of private judgment. Reading Mr. Bovill's specification for ourselves, and having before us what took place on the trial by jury in this case, we are unable to understand the grounds of the decision. We have seen that at the trial the jury were not asked any question as to the sufficiency of the specification, and that the objection to the claim as too wide was reserved for the Court, but in this judgment the Court seems to decline to consider this objection, because the jury had found that the specification was sufficient! Remembering that the judge deprecated the attempt of the defendant's counsel to enter upon evidence that his clients used exhaust so as to draw air through their stones, and that the blast is used for the purpose of sending air through stones, and that in the first claim the exhaust is to be used for the self same purpose, we observe with unfeigned astonishment that in this judgment Mr. Bovill's statement that he claims the exhaust only as applicable to the plenum of air forced through the stones, viz., by the blast, is interpreted as a direction to proportion the exhaust to the plenum caused by the blast, and his admission that the work of the two had previously been accomplished by the exhaust alone, as a caution against using the exhaust so as to perform that work. The ventilation of the stones, which is the very essence of the improvements, is thus declared to be an inconvenience. We shall see what consequences have resulted from this judgment. The fact that Mr. Robert Gordon, who had in 1844 patented the cold blast, was the real antagonist of Mr. Bovill in this case, explains the peculiarly restricted grounds upon which the case was contested. If the defence had been by perfectly independent parties, probably the patent would have been objected to on the grounds of the want of invention in the plaintiff's claim, and the insufficiency of the specification as to the third claim. The only instruction given as to how the invention of straining stive is to be practised is to strain it through suitable porous fabrics which could add very little to the sum of previous knowledge.

The success of Bovill *v.* Keyworth was quickly followed up by a Chancery suit in the Roll's Court, of Swaine and Bovill *v.* Gordon, in which a perpetual injunction was granted against Mr. Gordon to prevent him adding the exhaust to the blast he had patented two years before Mr. Bovill's patent for the blast. It was in this suit Mr. Bovill made the affidavit from which we have already quoted his description of his blast, patented in 1846. We now give from the same affidavit the description of his invention of 1849:—

"That I discovered the inventions described in the specification of 1849, by means of which, among other improvements, the plenum of air forced by the blast between the mill-stones surcharged with stive, or fine dust, is drawn by exhaustion out of the mill-stone case into a chamber, and the flour passes into the meal spout of the mill entirely free from dust."

Mr. Gordon appears then to have applied to the then Attorney-General, Sir R. Bethell, for permission to proceed by *scire facias* to repeal Mr. Bovill's patent of 1849, but the permission was withheld, upon the ground that it would be to re-open a question already decided between the parties in the action of Bovill *v.* Keyworth.

We have failed to discover any other action at law carried to trial in which the validity of the patent was contested.

In 1856, Mr. Bovill commenced an action at law against Messrs. Thomas Wren and Sons, of Stockton-on-Tees, but he abandoned it. In 1858 he commenced a Chancery suit against Mr. Christie, of Chelsea, but did not bring it to a hearing, and in 1863 he petitioned her Majesty for a prolongation of his patent, and the petition was heard before the Judicial Committee of the Privy Council. The Master of the Rolls presided on the occasion, and prevented the counsel for the opponents of the petition from contending that the patent was invalid, by ruling that their lordships would not entertain that question, but must treat the patent as a valid one. The patent was prolonged for five years,

Then an action at law was commenced against Mr. Christie, and he compromised it, and submitted to a decree in the Chancery suit which had been hanging on for four or five years. It is unnecessary to dwell upon the actions against various millers, such as Messrs. Marshall, Messrs. Hadley, Mr. Leicester, and others, which followed as none of them were contests upon the validity of the patent. We proceed to Bovill *v.* Goodier, instituted in the Rolls Court in 1864, and decided in April, 1866. During the hearing of the cause, Mr. Bovill was being cross-examined by Mr. Watkin Williams, counsel for the defendant, when the learned judge interrupted thus:—

Mr. Bovill being asked by Mr. Watkin Williams a question as to what he had seen in Mr. Kidd's mill at Isleworth, before 1859, said: "I do not know. I am in this position, my lord, that I filed a bill against Mr. Kidd, and I would ask your lordship whether I am bound to answer all these questions."

The Master of the Rolls: Have you filed a bill which is pending?—A. Yes; and in that case of Mr. Kidd's there is a great conflict with regard to the evidence as to the dates when he put up certain apparatus.

The Master of the Rolls: Then I do not think Mr. Bovill is bound to say anything which would disclose what evidence he intends to give in that case against Mr. Kidd.

The Witness: That is how it presses on me.

Mr. Williams. My Lord, I submit that a publication and a user by Mr. Kidd of this exhaust fan would be asked about.

The Master of the Rolls: The only thing is this. In compelling the plaintiff or the defendant to give discovery in chancery, we do not compel him to give any discovery which would disclose to other persons the evidence he intends to give to support the matters he puts in issue. Of course I cannot tell what there is in this suit against Mr. Kidd, but if it tends to produce that result, Mr. Bovill is not bound to give evidence.

Mr. Grove: My lord, I do not see any objection to Mr. Bovill being asked, what really is all which could be relevant in this case, namely, what he himself saw at Mr. Kidd's. Any information he got from witnesses which might be useful in his suit would not be evidence here.

The Master of the Rolls: The whole of Mr. Watkyn Williams' questions are addressed to this point—the validity of Mr. Bovill's patent. I should wish to have it argued beforehand as a separate and distinct matter, whether that is a thing I can go into.

Mr. Selwyn: I think your lordship will find it impossible to sever the two. The difficulty is this: Mr. Bovill's patent as it was when the case of Bovill *v.* Keyworth was tried, is one thing; Mr. Bovill's patent as opened by my friend, Mr. Grove, yesterday, is another and a totally different thing.

The Master of the Rolls: I shall hear you upon that, but at present here is the specification, a printed document.

Mr. Grove: The difficulty is this; that if we go into the question of validity *de bene esse*, it will occupy a long time. Of coure I must re examine Mr. Bovill upon all these matters.

The Master of the Rolls: What I think would be the most convenient course would be this. If you think that anything will turn upon the evidence of the witnesses you may ask them all to retire from the court, but I think the most convenient course would be for me to hear you state what facts you are advised or instructed you can prove, and to ask me whether upon these facts I will allow you to go into the question of the validity of the patent.

Mr. Selwyn: Your lordship sees the difficulty we are in is this. We say if the patent is one thing, we have not infringed it; if it is another, we say still we have not infringed it, but still it must be bad.

The Master of the Rolls: I cannot allow you to use that argument. Here is a patent, and of course every fair inference which can be drawn from that Mr. Bovill is entitled to on the one hand, and you are entitled to argue against him on the other, but because Mr. Grove gives a particular construction to this instrument I cannot on that account allow you to go into the question of the validity of the patent.

Mr. Selwyn: But your lordship sees the great inconvenience I am put to if I state my case before the principal witness on the other side is examined, and cross-examined, and after they have heard my case their principal witness is to be re-examined.

The Master of the Rolls: I do not think it is material on the question I have to determine. On the question of the validity of the patent, as now opened, I shall not decide in this case, and I inform you distinctly of that. The only question on which I shall hear any evidence, or any arguments on the facts, is whether I shall allow you an opportunity of contradicting it, but I shall not decide it, and therefore the materiality of the evidence to be given afterwards is not injurious or prejudicial to you. You, I apprehend, may obtain a *scire facias* unless the Attorney-General is of opinion that upon the evidence before him (and he is much more competent to decide it than I can), you ought not to be allowed to go into the question at law. I speak with considerable hesitation on a subject of common law, practice of which I know but little, but I apprehend that any number of persons may one after another take out a *scire facias* to contest the validity of a patent, provided the Attorney-General will allow them. If he will not, of course they have no case. Have you applied to the Attorney-General for a *scire facias*.—Mr. Selwyn: No, my lord.

Mr. Williams: My lord, after that intimation I will direct the examination of Mr. Bovill to the point, as to whether we are in a condition in this case to dispute the validity of the patent. I have a good deal to ask him with respect to that question, but I think there has been very great misapprehension as to the litigation about this patent, a very great misapprehension indeed.—The Master of the Rolls: You must go on.

After Mr. Williams had been for some time cross-examining the plaintiff as permitted, the following took place:—

The Master of the Rolls: What is the object of this, Mr. Williams?—Mr. Williams: I shall be able to show your lordship in a very few minutes. I thought the only one was Bovill *v.* Keyworth, and in that case the adjudication of the court has nothing whatever to with the validity of this patent.

The Master of the Rolls: You will have the record here, and you may argue upon that if you think fit.

Mr. Williams: It will not appear upon the record. There are several cases in which pleadings have been on the record, and nobody could possibly tell from the pleadings what the case was.

The Master of the Rolls: I assume you have evidence upon the subject if you rely upon it.—Mr. Williams: Certainly; but I wish to ask Mr. Bovill, because he would be the best witness on the subject.

The Master of the Rolls: His recollection of what was stated in that action, if I had evidence the other way, would not weigh with me at all.

Mr. Williams: It might dispense with the necessity of calling evidence.

The Master of the Rolls: I have got the specification here before me. The specification has been before the court at least on two occasions; once in a court of common law, and the second time before the Privy Council.

Mr. Williams: In the Privy Council your lordship expressly delivered the judgment there that the committee would not go into the validity of the patent, and you stopped Mr. Hindmarsh in cross-examining about that.

The Master of the Rolls: Still there was a great deal of examination on the subject. All they stated was, according to my recollection, that there was the Scotch patent. You have a specific course open to you. Why do you not apply to the Attorney-General for *scire facias*.

Mr. Williams: Perhaps we are more content with defending ourselves against this action.

The Master of the Rolls: You cannot defend yourself when you get a verdict against you upon the prolongation and a great number of verdicts.

Mr. Williams: I submit to your lordship the prolongation has nothing to do with it. In the judgment of the Privy Council, any attempt to go into the validity of the patent was stopped at once, Mr. Hindmarsh began to examine and your lordship stopped him.

The Master of the Rolls: For what reason? Simply because it had been established at law.

Mr. Williams: Upon the ground that the Privy Council will not go into the question of the validity of a patent.

The Master of the Rolls: Yes, always if it has never been established in any court of justice, but they will not grant a prolongation of a patent which they consider to be bad.—Mr. Williams: Further than that, Mr. Goodier is no party to any of the proceedings.

The Master of the Rolls: I am aware of that, but, as I said before, you may have a *scire facias*, and a hundred *scire facias* may be taken out by all the different persons.—Mr. Williams: It is new to say the defendant cannot defend himself in an action of this sort.

The Master of the Rolls: The practice of this court is, that if it has once been established at law it cannot be gone into in this court.—Mr. Williams: But we want to shew your lordship that it has never been established; we wanted to shew that Bovill *v.* Keyworth—

The Master of the Rolls: I cannot go into Bovill *v.* Keyworth.—Mr. Williams: We do not dispute the decision in Bovill *v.* Keyworth, not a bit.

The Master of the Rolls: If you say that the validity of the patent was not established in this case you must refer to the report.

Mr. Williams: This an action for three different things. In an action against a defendant he may contest the validity of the patent in one construction, and the judges held that they could not say it was not a good patent for a combination of the artificial blast with the exhaust, and that was the only question decided.

The Master of the Rolls: I will not hear you upon this point. I do not know how long this case is likely to last if you go into evidence, and the matters in issue in all the cases at common law, which have been mentioned to me.—Mr. Williams: I understand that is only upon the ground that Mr. Goodier is to be shut out from his defence.

The Master of the Rolls: Not at all, if he chooses to litigate the patent. He cannot do it here. The only question is, whether I am to give him an opportunity of doing it. He has an opportunity if he will apply to the Attorney-General.—Mr. Williams: In the meantime your lordship sees he must pay the damages of this suit.

The Master of the Rolls: It is not damages. It is an injuction; and costs.—Mr. Williams: He is advised he is perfectly right.

The Master of the Rolls: Why did he not obtain a *scire facias*?—Mr. Williams: That would not be a remedy at all. We should have to pay a large sum of money to Mr. Bovill.

The Master of the Rolls: No; I will stay the proceedings in the cause if the Attorney-General will grant a *scire facias*. When they were asking to be allowed to go into these details, I said, why do you not try it at law? What is the use of coming into equity when you know that the Court of Equity is bound by the proceedings at law, instead of taking the ordinary mode of trying the validity of the patent.

Mr. Williams: If that is your lordship's judgment upon the point, I feel perfectly relieved from cross-examining Mr. Bovill at all on the present point before the Court.

Mr. Grove: Probably the better plan would be to argue the point.

The Master of the Rolls: No doubt this is a question to be argued, and I will allow every assumption to be made for the purpose.

Mr. Selwyn: I am not prepared to argue it now.

Mr. Grove: Then I must re-examine the plaintiff *de bene esse.*

The Master of the Rolls: I do not think you can if I stop the examination by my observations. Mr. Williams has not had his examination *nil*; and he forbears in consequence of my intimation that, in my opinion, the examination is useless: therefore what can be the use of your re-examining.

Mr. Grove: Very well; your lordship has heard several questions asked Mr. Bovill as to previous examinations. As long as it is clearly understood and entered upon the notes that the examination was given up by my learned friend, and that I am stopped, it answers my purpose; but I do not want it hereafter to be said, Mr. Bovill stated a thing in his examination which he would not have stated if he had been re-examined probably.

The Master of the Rolls: If any person is to be injured, I must request Mr. Williams to go on with his examination, and I promise not to interfere at all.—Mr. Williams: My lord, I feel that is throwing too great a responsibility upon me.

The Master of the Rolls: It throws no responsibility upon you.—Mr. Williams: I always feel some relief when I know the learned Judge has stopped me from going too far.

The Master of the Rolls: You are not going too far for what you consider to be the issue; but I consider the question does not arise.—Mr. Williams: That throws an amount of responsibility upon me which I am not prepared to accept. I am quite willing to follow the directions of the Court.

The Master of the Rolls: I have thought that the question does not arise; and it was because I thought so that I interposed before. The question does not arise in this case.—Mr. Williams: I would be throwing away time altogether to go on if that is your lordship's view.

The Master of the Rolls: It would be quite useless in my opinion; it does not arise at present. It would be useless of Mr. Grove to re-examine.—Mr. Grove: I am perfectly content if the case rests here. I am only anxious that on some future occasion Mr. Bovill shall not be asked did you say so and so, when, although what he has said may be perfectly true in cross-examination, the meaning of it may require to be properly explained by re-examination.

The Master of the Rolls: It is me stopping the examination; I do not see what is the use of your re-examination.—Mr. Grove: If it is taken that Mr. Bovill is not re-examined, and that his answers have been given in cross-examination without his having an opportunity to give his full answer, which two or three times Mr. Bovill was stopped in them, I am quite satisfied. There is another point which I ought to mention to your lordship, in order that we may not have a discussion upon it hereafter. Your lordship has not said at present, as to the infringement, what you propose to do; and I should only re-examine Mr. Bovill as to matters which touch the question of infringement, and leave alone the question of prior use.

The Master of the Rolls: The question of infringement is entirely open to you.

Mr. Williams: We have not touched upon the question of infringement.

Mr. Grove: You have touched upon questions which greatly affect the infringement, and I should re-examine upon that.

The Master of the Rolls: I had thought that all Mr. William's questions applied to the validity of the patent.

Mr. Grove: But several of them apply to infringement. Your lordship may recollect he was asked, on seeing the defendant's mill, whether he considered he infringed or not.

Mr. Selwyn: I do not object to my learned friend re-examining if he thinks fit.

The Master of the Rolls: I cannot make him examine upon the question of infringement when I do not think the witness has been cross-examined upon infringement. The infringement is a question before me which I have to determine. I do not wish to stop a single question upon the point of infringement, if you can keep it apart from this—that I consider the legal validity of the patent has been established at law, and that the Privy Council has acted on the fact of such legal validity having been established; that I also consider myself bound to act upon the legal validity of the patent having been established, but infringement is a totally different question. Whether the particular plan adopted by the defendant in this case is an infringement of Mr. Bovill's patent, such as appears on this specification, is a totally different matter; on which, of course, any questions that Mr. Watkyn Williams may ask will be strictly relevant.

Mr. Selwyn: Yes. The view we take is this, that it is almost impossible to separate the two questions of validity and infringement, because we say if Mr. Bovill's patent is such as it is stated to be, and such an extent as to render it possible that the present defendant has infringed that, then it will necessarily follow it is bad.

Mr. Grove: That is a matter I am quite prepared to argue.

The Master of the Rolls: Then I must ask Mr. Watkyn Williams to ask any questions which he thinks relevant to the infringement.

On this footing the case was afterwards conducted.

Of course this determined the manner of conducting the case afterwards, but the learned judge seems to have forgotten all about this when he pronounced his judgment, which we print in *extenso*:—

The Master of the Rolls: This suit is instituted by the plaintiff to restrain the defendant from infringing a patent obtained by the plaintiff for improving the grinding of flour, for collecting and utilising the stive or small particles of flour which formerly was almost all lost, and occasionally or generally created an injurious dust in the body of the mill itself. The defendant by his answer contests both the validity of the plaintiff's patent, and also the fact of the infringement of it by him the defendant.

The history of the plaintiff's invention is an instance of the troubles which, in the present state of the law, await a successful inventor. The patent in question was taken out by the plaintiff in June, 1849. Since then he has been engaged in constant and expensive litigation up to 1863, when the patent was prolonged by the Privy Council for five years. This, however, has not produced any termination to the litigation of which the present suit is an instance. At the same time much of this is incidental to the nature of things. The claim of having made an invention is not to preclude others from using an old process and old machines, because some person *bonâ fide* believes that he has invented what, in truth, has been long known; nor ought the fact that one person has infringed the patent, being ignorant that the discovery of the patentee was not a new one, to preclude another person from showing that it had before been known and been in use. It may well be that Mr. Bovill invented the process he has patented, and yet that the same process may have been used by other persons before the date of Mr. Bovill's patent; and it would be injustice to stop the use of a process long employed, because some other person had subsequently discovered the same process. It would also be unjust, because one person has been unable to prove that the discovery was not new, to prevent another from doing so, and binding him by a proceeding over which he had no control, and of which he knew nothing. The consequence is, that in almost every case the plaintiff has to establish his case from the beginning against any fresh person who chooses to impugn the patent and to contest its validity. At the same time, the law properly attaches superior rights to a patentee who has established the validity of his patent, to those which belong to a patentee who has not done so. The former stands on a different footing, and, though the patent may be contested by fresh persons, he will receive protection until the invalidity of it is shown. The distinction hitherto made by courts of equity has been where the validity of the patent has not been the subject of any legal proceedings, the patentee must prove its validity at law before the Court of Equity will protect him; but having once established its validity, then the Court of Equity will protect him against any other person until that person proves its invalidity. Accordingly, the first thing I have to consider in this case is the fact, whether Mr. Bovill has established the validity of his patent in a court of law? If he has done so, it has been by the case of Bovill *v.* Keyworth, in 7th Ellis and Blackburn. The defendant contends that this case does not establish the validity of the plaintiff's patent, and that, if it does, it is for an invention which is not infringed by him. The way in which the defendant puts his case may be shortly stated thus: if the patent be such as is established by the case of Bovill *v.* Keyworth, then the defendant has not infringed it; but if the patent be such as the plaintiff contends that it is, then its validity is not established by the case of Bovill *v.* Keyworth, and the patent so alleged is invalid, and principally by reason of its want of novelty.

In order to estimate the value of this argument, it is necessary to consider what the invention is which is described in the specification, and what the case of Bovill *v.* Keyworth has decided. Now, I am reading it from the bill, which is exactly in the same words, at the 6th paragraph. "Firstly, in an arrangement for ventilating the grinding surfaces of the mill-stones, and the introduction of air through the top-stone (when fixed), either by blowing or exhaustion. Secondly, in exhausting the air from the cases of the mill-stones, combined with the application of a blast to the grinding surfaces. Thirdly, in separating the stive or dust of flour from the air when exhaustion or blast is employed to facilitate grinding, and preventing the dust and waste in the mill." Then, further on he says this: "In carrying out the second part of my invention, when working mill-stones with a blast of air, I introduce a pipe to the mill-stone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber as hereinafter described, by which the dust in the mill is avoided and grinding improved. And this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the mill-stones without a blast, this having before been practised, as above mentioned. The third part of my invention consists in straining the stive or air which is surcharged with fine flour, through suitable porous fabrics which retain the flour and allow the air to pass through; and this I accomplish by exhausting the air from the mill-stone case, or other closed chamber, receiving the meal from the stones by means of a fan or other exhausting machinery, and blow the stive so exhausted into a chamber having its sides and top formed of one or more thicknesses of suitable porous fabrics, to allow the air under pressure to pass out deprived of the flour by means of this filtration. I also obtain the same result by placing the filtering chamber between the stone-case or chamber receiving the meal and dust from the stones and the exhausting machine. The stive or dusty air is then sucked through the filtering fabrics, instead of being blown through, and the air passes away clean as before."

Now, it is argued that this is merely a patent for the combination of these three processes, each of which was old; and that all that Bovill *v.* Keyworth has done is to determine that the specification correctly describes an invention consisting of the combination of the three; that this combination is new; and that in this consists the invention, and that Bovill *v*, Keyworth does not go beyond this. I have, therefore, in the first instance, to consider whether the case of Bovill *v*. Keyworth has established the validity of each of these three matters separately, or only in combination with each other. The judgment of the Court of Queen's Bench appears to me to determine the validity of each. Lord Campbell says in the first part: "The whole of the plaintiff's process, if the combination is new, is certainly the subject of a patent; and so would the part, No. 2, if taken separately, for exhausting the air from the cases of mill-stones, combined with the application of a blast to the grinding surfaces, as they introduce very important improvements in manufacturing wheat and other grain into meal and flour." Now, that appears to me to point out that the No. 2, taken separately, is also described as an invention by itself and not in combination. That is made more clear afterwards. He says if the specification does not point out the mode in which this is done it would be invalid. "But we are of opinion that the specification, on the face of it, cannot (as contended) be pronounced, in point of law, to be bad in this respect; and we are of opinion that the evidence adduced at the trial shows it to be quite sufficient." He says: "The exhaust produced by the pipe and fan is to be proportioned to the plenum caused by the blast, taking care not to produce the inconvenient current of air against which a caution is given. How can a Judge take upon himself to say that this may not be enough to enable a workman of competent skill to construct the machinery?" In a further place he says: "We do not think it necessary to try to reconcile the different parts of the specification (which are somewhat conflicting), or to give any positive opinion upon this question, for, supposing the patent to be for a combination consisting of several parts for one process, we are of opinion that the defendants are liable in this action for having used a material part of the process, which was new, for the same purpose as that mentioned in the specification, although they did not at the same time use all the parts of the process as specified. If the fixed upper mill-stone were clearly described by the plaintiff in the statement and diagram to be found in his specification as part of the combination for which he took out his patent, as No. 2, is a material part of the combination, and was new, we are of opinion that they cannot lawfully use No. 2 for the same purpose, by substituting a rotating upper mill-stone for a fixed upper mill-stone, or by resorting to any other equivalent for any other separate part of the process specified."

Now, I am of opinion that that establishes the separate parts of the specification. Great stress was laid in the argument upon these words: "And this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the mill-stones without a blast, this having been practised as above mentioned." But I am of opinion that the application of the exhaust to drawing away the plenum is a material invention of the plaintiff by itself, although the combination of it with the other parts of the invention may be properly and validly claimed as another part of the plaintiff's invention; and this double fact appears to me to be established by the passages in the judgment to which I have referred. There is also this preliminary obstacle in the way of the defendants, on the question of the validity of the patent—namely, that the specification of the plaintiff is a written document, of which the construction must be the same in a Court of Law as in a Court of Equity; and the Court of Queen's Bench has determined that this patent is valid—that is, that the invention was new; that it was useful; and that it is sufficiently described in the specification. The objections urged against it before me obviously were urged at law, and were present to the mind of Lord Campbell when he delivered his judgment; and the words I have read appear to me distinctly to point to the validity of the patent, not merely in respect of the combination of the matters there mentioned, but also of the validity of the separate parts, which are distinctly claimed as inventions by the plaintiff in his specification, assuming those separate parts to be new. I am of opinion, therefore, that the sucking away of the plenum of dusty air forced through the stones is a separate distinct part of the invention of the plaintiff claimed by his specification; and that the Court of Queen's Bench (this is number two in fact) has determined that this is valid. I admit that this decision would not be conclusive at law in a fresh case, nor would it be binding on me if evidence were now produced which was not before the Court of Queen's Bench; but on this point, I do not find that any evidence has been laid before me which was not before the Court of Queen's Bench, with the exception of the French patents; but to those I give little weight. I think that they all differ essentially from the inventions of the plaintiff, as to the mode of drawing away the dusty air from the plenum. They do not appear ever to have been successful. Indeed, the fact, that the defendant had not used them, and that no one uses them, and that they have all expired, is a proof that they are not the same as that of the plaintiff, which is confessedly a process of great value. I am further of opinion that the decision of the Court of Queen's Bench also establishes the validity of the plaintiff's patent as regards the third invention—namely, the use of the stive-room, and that this is effected in combination with the exhaustion of the air from the mill-stone cases. It does not appear to me that the forcing the air into the mill-stone case from above is a necessary part of this invention. The invention, as described in the specification, and as established in the Court of Queen's Bench, consists, I think, in the employment of a sufficient power to suck away the dusty air in the mill-stone cases, and the discharging it through a porous fabric, by which the fine flour is retained, and the air is allowed to escape. It is true that the air which is drawn away from the mill-stone case must find its admission into the mill-stone case from some separate entrance; but the invention now before me, as I understand it, consists in exhausting the dusty air in that case in such a manner as to draw it all off without employing such a force as to draw with it the meal; and to transmit the air so drawn off through a chamber formed wholly or in part of a porous fabric, which will retain the dusty particles of flour and allow the air to escape.

The French patents which relate to this subject appear to me to be quite distinct from that of the plaintiff. I think it unnecessary to go through them in detail. The idea was probably present to the mind of one or more of the inventors; but they have failed in discovering the method by which they could exhaust the dusty air merely without drawing the meal with it; and I am of opinion that the validity of the patent as now claimed by the plaintiff is established by the decision in Bovill *v*. Keyworth.

(*To be continued*).

## THE ABRADING AND TRANSPORTING POWER OF WATER.

(*Continued from page* 102)

In our last issue we briefly drew attention to the consideration of the effect of the abrading and transporting power of water in influencing geological questions; its action in the formation of deltas, its influence on river channels, the formation of bars at mouths of rivers, and the effect of shortening rivers, and in continuation we now propose to treat of other questions involved in or effected by the consideration of this most important subject.

### The Effects of Embanking Rivers, Considered in Connection with this Question.

In a previous article we have tried to show that in the present day the formation of deltas is a work of great *time*, and from Mr. Ellet's estimates it would appear that it must have taken 45,000 years to raise the delta of the Mississippi from the level of the sea to its present level. (See page 32 of Ellet on the Mississippi), whilst Mr. Login estimated that it probably has taken 13,000 years to raise the delta of the Irrawaddy to its present level. (See proceedings of the Royal Society of Edinburgh for March, 1857). Having already roughly estimated the general rise of a delta at two inches in a century, and shown that along the banks of the river it is much greater,—viz., as much as 5 inches on the Nile at the head of its delta, we must next consider the consequences of such variation, for it is evident that if this difference in deposits was constantly taking place, in time the river would rise high above the neighbouring country.

This is what we find to be the case, and on almost all rivers which flow through alluvial plains, we find the river bank much higher than the plain. At the distance of a mile or two back from the river, on the Mississippi, some times the river bank exceeds the height of the plain by 15ft.; so, supposing the increase of the rise of the bank over that of the delta to be 5 — 2 = 3in. in a century $\frac{12}{3}$in. × 15ft. × 100 years = 6,000 years, or the river has followed its present course some 6,000 years. The changes are, however, greater than this, most probably; for with large rivers we find a constant falling-in of the banks and the deposit, owing to local circumstances, is much greater, though the general rise may be a work of centuries. The general deduction, however, is that most probably an incalculable lapse of *time* took place in preparing the earth's crust for man, and that, except at isolated points, the changes now going on are so slow that, as far as we are affected, the ground that we stand on may be looked upon as permanent. These isolated cases, however, are sufficiently numerous, and of such magnitude, as to prove to us that certain powers still exist which are able to produce at any moment a complete convulsion of nature.

Were we only to think of these possible convulsions, nothing would be done to protect our lives and property from the dangers to which we are daily exposed; but our inaction on these grounds would be about as absurd as to put a stop to house building, because from time to time we hear of houses being destroyed by fire.

Having, therefore, arrived at the conclusion that, in protecting a country from being periodically inundated, there can be no doubt that we are preventing its general level from being raised, and that we are aiding the river to rise more rapidly above the country, the question is, at what rate do we assist this action by embanking rivers?

As the abrading power of water increases with the velocity, it is evident that, confining a river within its banks, is to increase the velocity; and, therefore, the tendency is rather to scour out the bed along the portion embanked. There is, therefore, at once a tendency to increase the cutting on the bed or banks by this greater velocity. If the bed be chiefly affected, the result is that the channel of the river is kept better in soil; and this, it is believed, will generally be found to be the case where any portion of a river is embanked.

The transporting power of water, however, is not increased so rapidly as we would at first sight imagine; as it is supposed to be inversely as the depth by some proportion yet to be discovered by experiment or observation. Consequently, as the depth of water in a river must be increased by its being embanked, the transporting and abrading power may be but slightly affected by the increased velocity.

The question therefore is, how is it that the effect of embanking a river is to raise the bed and banks, which is the case on some rivers? The reason is that rivers such as the Po have a great slope, and fall into a shallow tideless sea, so by embanking them the river has more power to push forward the larger proportion of solid matter the water holds in suspension, and the sea, being tideless as well as shallow, this solid matter is deposited near its mouth, and thus the bed must be raised more quickly than where the sea is deep and is assisted by tides and currents to carry the earth brought down by the river far out to sea. Mr. Ellet, in his work on the Mississippi, at pages 75 and 76, goes into this question, and Capt. Humphrey and Lieut. Abbot, in their report, at pages 414 and 415, show that the elevation of the bed of the Po is not so great as was at one time thought. With respect to the effect of embanking the Mississippi, these officers, at page 436, say:—"We find that a prolongation of the river 25 miles into the gulf will be required in order to elevate its surface one foot at Fort St. Philip. Even at the present rate of progress of the delta, this extension would not be accomplished in less than five centuries."

There, however, still remains another important point to be considered affecting this question which should not be lost sight of.

When a river inundates a country, the inundation water returns to the river after the flood begins to subside, along with any rain water which may fall in the neighbourhood which is drained by the river. Now, it has been already shown that when a river rises so high as to be able to overtop its banks, and thus inundate the low lands on either side, it parts with a very large proportion of its load of solid matter held in suspension, and therefore returns to the parent stream under very different conditions to that in which it left it. This comparatively pure water, on returning to the main river, is no longer obstructed in its flow by vegetation, &c., and, as it attains its former velocity, it has again the power to pick up and hold a considerable load of solid matter in suspension, and therefore it at once begins to attack the bed and banks, for any increase to the velocity must cause scour. This at once explains why rivers which are rising, or, during the high flood do not cut much into the banks, for all the water then has its proper load, but as soon as the flood begins to subside, and this inundation water drains back into the river, then begins the violent attack on the river channel. Such being the case, the effect of preventing this inundation must, as a natural consequence, prevent in a great measure this excessive cutting, for the water would come down the river with its proper load due to its velocity. Embanking rivers, therefore, would not only protect the country from injurious inundation, but indirectly protect the banks from the violent cutting which we find taking place as soon as a flood begins to subside. It has been supposed that this tumbling in of the banks is owing to the water having impregnated the soil, and that thus the soil loses its cohesion, while its weight is increased; but, so far is this *not* the case, that the soil of the bank generally appears quite dry, and often clouds of dust and sand are formed by the falling in of this dry soil.

Considering, therefore, the protection embanking large rivers would afford to both life and property, and having shown that ages on ages must elapse before any important change can arise in the general level of the river's bed with relation to that of country where rivers are embanked, it is evident that a correct knowledge of the abrading and transporting power of water, which is only to be arrived at by experiments and observations, would enable the engineer to deal with this question in an exact manner and on acknowledged principles.

### ITS EFFECTS IN RECLAIMING LANDS FROM THE SEA.

Possibly hardly a better example could be brought forward of the necessity for a proper knowledge of the laws which regulate the abrading and transporting power of water, than the closing up of reclamation banks.

In January, 1864, a paper was read before the Institution of Civil Engineers on this subject; and this paper, along with the discussion, is to be found in Vol. XXIII. of the Proceedings of the Institution of Civil Engineers.

Various opinions are there given, and the general conclusion arrived at was sound—namely, that the embankments should be raised by degrees, as explained by Mr. Vignoles. The object of this paper was to determine the velocity with which the tide would flow into a gap 800ft. wide, with a rise and fall of 15ft. at spring tides; this gap to be closed, and thus to reclaim about 7,000 acres of land between the mouths of the Blackwater and Crouch rivers, which required a sea-wall ten miles in length. The lowest level of the land to be reclaimed was to be 4ft. above low-water spring tides, so as the rise and fall during neap tides was 11ft., thus this land would be $\frac{15}{2} - 4 = 3\frac{1}{2}$ below half tide; again, $\frac{11}{2} = 5\frac{1}{2}$, and $5\frac{1}{2} - 3\frac{1}{2} = 2$ft. above low-water neap tide. Again, as the area equalled 7,000 acres, and the length of wall ten miles, the average breadth of the space to be enclosed would be a little over one mile, or say 5,500ft; or the volume of water would be $\frac{(15 - 4 = 11)}{2} \times 5500 = 30250$ cubic feet of water, which would have to pass over any one foot of the site of the embankment.

Taking $\frac{15 - 4}{2} = 5\frac{1}{2}$ as the average depth, and the time of rise only at four hours, the mean velocity flowing towards the land would be

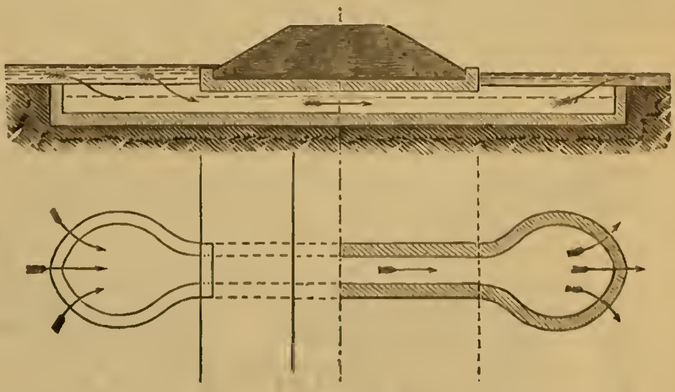
$$4 \times 60 \times \frac{30250}{60 \times 5{\cdot}5} = 0{\cdot}38\text{ft. a second.}$$

But as the probable flow over the site of the proposed sea-wall may be ten times this velocity, or rather over $2\frac{1}{2}$ miles an hour, it is evident that 9-10ths of the sea-wall may be completed without adding to the natural velocity of the water. Therefore, as this water must have a load of solid matter held in suspension due to this velocity, no action could take place on the ends of the embankment, nor on the open space left between the ends of the embankment, which would be a gap a mile broad; but the moment this gap came to be diminished, an increase to the natural velocity would begin, and continue increasing till, as shown by the paper of Mr. Heppel, the velocity would increase to $1{\cdot}1\frac{1}{3}$ft. a second during the efflux, if contracted to 800ft. wide and $11\frac{1}{3}$ influx, or some *four times* the natural velocity.

What makes matters still worse is, that the water, while flowing into the enclosed space, must have a load of solid matter proportional to its velocity; but as this water, when once it is admitted into the enclosure, must come to rest, it will part with the greater portion of this load, and when the efflux begins, the water being thus freed of its earthly matter, will be all the more ready to cause abrasion, and consequently it is during the ebb tide we must look for most frequent accidents to the embankment.

To guard against this, the remedy appears to be simply to prevent the return of the water to the river, and to keep it confined within the enclosure up to the level to which the remaining mile may be raised; but as this portion must be new and unconsolidated, sluices, or what may be called inundation syphons, through the completed portion of the bank, should be provided so as to lower the surface of the water within the enclosure a few inches below the level of the top of the uncompleted portion of the sea-wall; these syphons would afterwards be necessary for drainage purposes.

The peculiarity of this description of syphon is, that it is bell, or rather spoon-mouthed, and the crown of the arch should be below or on a level with the lip of the spoon thus:—



for by such an arrangement it is evident that the velocity through this syphon under the embankment may be five times, or even ten times as great as where the water approaches or leaves the syphon, and thus all danger of cutting is avoided.

From the above, therefore, it is hoped it has been made clear that a correct knowledge of the abrading and transporting power of water is all important in reclaiming lands from estuaries of the sea; and when once it is properly understood, the difficulties hitherto experienced will probably disappear, so that an engineer can set about reclaiming land with the same certainty as he makes a railway.

### The Use of Inundation Syphons.

In countries where rivers when in flood overflow their banks, and a large volume of water passes down the valley on either side of the main river, it often becomes a very difficult question how to pass off this inundation water when it has to be crossed by an embankment.

The cross section of such valleys shows, that the highest ground is immediately at the river bank, and that there is a considerable fall right and left of the main stream. This inundation water being comparatively shallow, and having often to flow either through standing crops or jungle, is very sluggish in its flow compared with the main stream, and, in consequence, the water holds very little earthly matter in suspension.

As the ground is lower than at the river bank, it is evident that all this inundation water cannot drain back into the main river. To provide sufficient water-way for this sluggish water would entail very great expense, and to contract the water-way increases the velocity both of approach and egress; that is, it increases the transporting and abrading power of water, so that a scooping-out action takes place both above and below bridge, often causing the destruction of the work, and a breach in the embankment, which is sometimes so large that the main stream takes to it, deserting the large bridge.

Now, the question is, how can this low ground be drained without involving a great expenditure? It is believed that this can be done by inundation syphons, which have enlarged openings in both sides of the embankments for the ingress and egress of the water, but a very contracted channel below the embankment itself, as shown in the engraving on page 129. By this means the water may be forced into the main channel during a flood, and pass off under the large bridge; but the moment the river falls below its banks, what remains of the inundation water will drain off by these inundation syphons. During the flood, however, the inundation water will stand much higher on the up than the down stream side of the embankment, and owing to this head of water there will be a great rush through the contracted masonry channel under the embankment, but not greater than it can stand; but the syphons having proportionately large openings to receive the water at its natural velocity, and to pass it off at the same velocity, there can be no tendency to cutting either up or down stream.

It is also evident that the use of these syphons, where rivers are embanked, would admit of irrigation being carried on through the embankment.

(*To be continued.*)

## LAUNCH OF THE TURKISH IRONCLAD "AVNI ILLAH."

A beautiful armour-plated sloop of war, which was named the *Avni Illah*, was launched from the yard of the Thames Ironworks and Shipbuilding Company, Blackwall, on the 28th of April. The design of this vessel is an extension of the system first introduced by this company when constructing the Greek iron-clad last year, and which has already been noticed in the columns of The Artizan. In that case it will be remembered that there was a fixed tower or battery amidship, mounting two guns, but in the present instance the increased tonnage of the vessel admits of the erection of two towers, each mounting two guns, making the shape of the battery somewhat similar to the body of a violin, as will be seen upon reference to the annexed engraving. The object in making the battery of this peculiar shape is to obtain the greatest possible arc of training for each of the guns. Thus in four of the ports this arc amounts to 100° while in the two forward ports it is 95°, and 89° in the two aft ports. By this means a line of fire is obtained parallel with, or rather slightly converging towards the keel forward, and within 10° of a line with the keel aft. In addition to these advantages, each of the ports can be used for broadside firing, as will be seen by the dotted lines in the drawing, the full lines showing the extreme range from each port. All four guns can thus be fired on the broadside converging to one point at a distance of 110yds. from the ship's side; the fire of three of the guns can converge at a distance of 16yds. from the ship, and from two of the guns within the breadth of the vessel.

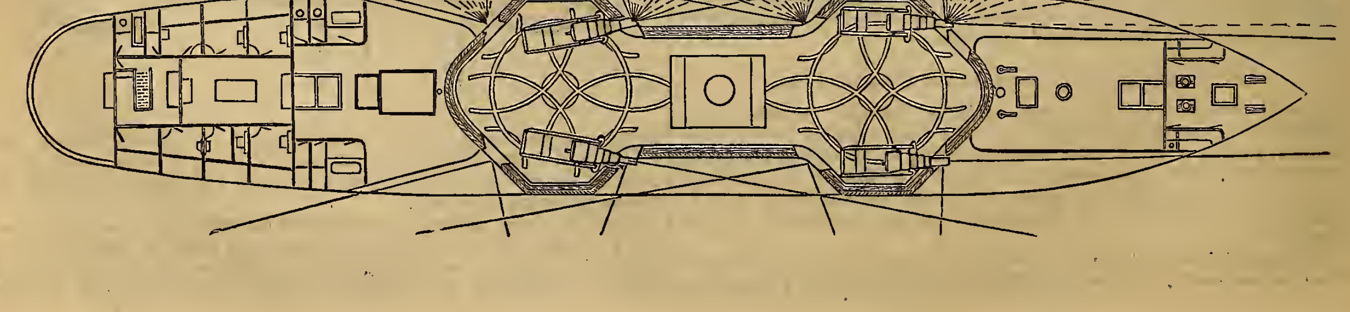
This form of battery is peculiarly suitable for fighting "end on," as the two forward guns can be fired in a direct line with the keel, and the two after guns within 10° of the keel. For this system of attack Mr. Mackrow's design is even better adapted than the turret ships as at present built in this country, as it cannot be said that they command a line of fire parallel with the keel.

The object of this design was to obtain as far as possible, the advantages of the turret commanding an all-round fire without the disadvantages of the opening in the deck in which the turret revolves, and the necessity of having the bulwarks made to fall down. These bulwarks, which are made of iron, are fixed inside of the lines of fire, and being decked over afford convenient accommodation for the crew. The freeboard to this gunwale is 11ft. 6in., the ports being 6ft. 6in above the water line. The vessel is, therefore, thoroughly seaworthy, while she would be a comfortable ship even in bad weather, and very seldom unable to use her guns. Another advantage possessed by this system over the turret may be mentioned, although it is sufficiently obvious, viz., the absence of all machinery for revolving the turret, and the consequent liability of the turret to become jammed.

The following are a few of the leading dimensions:—Length between perpendiculars, 225ft.; breadth, 35ft. 6in.; depth, 20ft.; draught (loaded), 16ft.; tonnage, 1,400 B.M.; armament, 4 12-ton guns (or 300 pounders); armour, 6in. plate on 10in. teak backing.

The engines, which are of 400 horse-power, driving a single screw, were constructed by Messrs. Ravenhill, Hodgson, and Co., and a speed of 13½ to 14 knots is anticipated.

A second vessel of the same tonnage and design is being built on the Thames by Messrs. Samuda, Bros., and will be launched very shortly. Her engines are also of 400 horse-power, by the same makers (Messrs. Ravenhill, Hodgson, and Co.), the only difference being that she is a twin screw. This will consequently be an excellent opportunity for testing the relative merits of the twin screw system as compared with the older plan.



## REVIVAL OF SHIPBUILDING AND ENGINEERING AT NORTHFLEET.

On the 8th ult., we had the pleasure of being present at an event which, though comparatively speaking of no great importance in itself, may still be looked upon as indicating a revival of shipbuilding and engineering enterprise at Northfleet—we refer to the occasion of an inaugural launch from the shipbuilding yard of Messrs. Allibon, Noyes, and Co., of an iron screw steamer, intended for the combined purposes of cargo and towing. The day's programme also included the trial of Messrs. Allibon and Manbre's patent vertical annular boiler, and the working of a pair of horizontal engines, constructed for the Government of Peru. The Rosherville iron works are situate about five minutes' walk west of the Rosherville Pier, immediately adjoining the site of the once celebrated Northfleet Dockyard. The works have only been fairly started during the last six months; we were consequently scarcely prepared to see the progress which has been made in such a short time, and it is to be hoped that the venture will be successful. and that engineering and shipbuilding will be prosperous, where for a long time the trade has lain dormant. The vessel launched was named the *Yquitos*, out of compliment to the Peruvian Government for whom Messrs. Allibon and Noyes have executed some extensive works, by the direction of Daniel Clark, Esq., chief engineer to the Government of Peru. Yquitos, we may add, is the name of a town in the interior of the country; the seat of the Government engineering works. The vessel was christened by Madame de la Quiutana, wife of the consul-general in England of the Peruvian Government. The *Yquitos* is fitted with four water-tight bulkheads, and although she has been modelled with a view to obtaining high speed, there is internally a roomy capacity for cargo-carrying.

The following are some of the principal dimensions:—Length (between perpendiculars) 65ft.; breadth moulded, 12ft. 6in.; depth, 7ft.; draught (light) 3ft. 6in. forward, and 5ft. 6in. aft; carrying capacity, 25 tons; tonnage (o.m.) $47\frac{74}{94}$. The frames are spaced 21in. apart throughout; there are four bulkheads, and the bulwarks tumble home at an angle of 30°, as it is found by experience that these are very liable to damage when going alongside, or pushing through other craft, if made straight. The engines are of the direct acting inverted cylinder class of 30-horse power nominal supplied by two boilers (Allibon and Manbre's patent, a drawing and description of which will be found in the present number of The Artizan), which are intended to work at a pressure of 120lbs per square inch, and are supplied by a small donkey engine.

A sister vessel to the *Yquitos* is nearly finished, and will shortly be launched. The pair of stationary engines, which appeared very well finished, are of the collective power of 25 horses nominal. The diameter of the cylinders, two in number, 13¼ inches, and the length of stroke 2ft. 4in. They are fitted with variable self-adjusting cut-off valves, designed by Mr. George Allibon, for driving machinery where the load is constantly varying, such as in the case of saw-mills, printing machines, &c. They are supplied with steam from one of Messrs. Allibon and Manbre's patent vertical annular boilers, 6ft. in diameter, and 14ft. high containing 300 feet of heating surface.

## INSTITUTION OF CIVIL ENGINEERS.

### ON THE OUTFALL OF THE HUMBER.

By Mr. W. Shelford, M. Inst. C.E.

The estuary was described as the outlet for the fresh waters from a drainage area of 10,500 square miles, or one-fifth of the whole area of England; but the present paper only treated of the outfall, the observations being arranged under four heads.

I. The facts in connection with the past and present condition of the outfall and of its peculiar feature—Spurn Point. Under this head the district was said to consist geologically of diluvial clay resting upon chalk, of which the surface was proved to be below the bed of the river at its outfall. The extent of the marshes and the fens adjoining the estuary and their levels were then given, and it was shown that the area of the reclaimed land below high water spring tides at sea was 290 square miles, while the present area of the estuary at high water was only 110 square miles. It was also shown that the marsh banks were generally repaired in the thirteenth century. The waste of the Holderness coast, from Bridlington southwards, was stated to average 2¼ yards per annum, and it was inferred that 1000 years ago the coast line must have been at least 2,250 yards farther east. It was thought possible, that the promontory might then have had a short point, with an ebb channel and a good roadstead close to it, and that here the Danes landed in A.D. 867. Here also gradually rose the town of Ravenser, which was one of the most flourishing ports of the kingdom in the fourteenth century. In 1250, an outlying hamlet of this town, called Ravenser Odd, originated. It was upwards of a mile distant from the mainland, and the access to it was from Ravenser by a sandy road scarcely elevated above the sea. In 1289, the Grimsby people claimed certain privileges there, calling it an island, and probably basing their claims upon its previous insular character. In 1860, Ravenser Odd was totally annihilated by the floods of the Humber and inundations of the great sea. The last mention of Ravenser itself was in 1552.

In 1622, it had been said that "parcel of the Spurnhead, which before did adhere to the continent, was torn therefrom by the sea, and is now in the nature of an island." In 1676, Angell's lights were authorised, in consequence of a broad long sand which had been thrown up at the mouth of the Humber six or seven months before. Smeaton thought that this sand had afterwards become connected with the mainland, and so formed the Spurn Point of his day.

The author proceeded to state that Sunk Island was spoken of as a novelty in 1667, and was described as an accumulation of sand and mud, also that Frismersh, or Fresh Marsh, formerly occupied its site, and was destroyed soon after 1362.

The leading features of the outfall were then pointed out, as shown by the following charts, of which cartoons were exhibited, viz., Greenville Collins' Chart of 1684, Robert Mitchell's of 1778, Hewett's of 1828, and Calver's of 1852. According to Smeaton, "Spurn Point was a necessary appendage to the cliffs of Holderness, and was in a continual state of travel southward and westward: the southward movement being accompanied by a corresponding encroachment of the river on the Lincoln Coast, and the westward movement by the abrasion of the coast of Holderness by the sea." It appeared from these charts, that seaward of Spurn a large accumulation of shingle had taken place, and that on the Humber side extensive accretions, including Sunk Island, had formed. Also, that the main flood stream set in to the south of the Bull sand, and the ebb stream set out to the north of it.

The southward movement of Spurn was shown to have varied, and to have been as follows:

| | | | |
|---|---|---|---|
| 1676 to 1766 | 20 | yards | per annum. |
| 1766 „ 1771 | 56 | „ | |
| 1771 „ 1786 | 10 | „ | „ |
| 1786 „ 1851 | 4.7 | „ | „ |
| 1851 „ 1864 | 8.7 | „ | „ |

The westward movement was shown by the history of the lighthouses to have averaged 3 yards per annum since 1771. It was also stated that since 1863 an attempt had been made to arrest this movement, and the danger of so doing was pointed out.

II. The ascertained alterations in the tidal régime. Under this head evidence was offered to prove, that the tidal range of the Humber at Hull increased 3ft. between 1852 and 1828, and 2ft. between 1828 and 1725, making 5ft. since 1725; and if the increase had been continuous since the rise of 4ft., recorded to have taken place about 1357, it would make a total increase of 9ft. in about 600 years. Evidence was also offered, which was considered sufficient to justify the general conclusion, that the tidal capacity of the Humber below low water had increased between 1828 and 1852.

III. The relative value of tidal and fresh water at the outfall. After demonstrating that the discharge of a great flood from the drainage area would only equal a fourth of the tidal capacity, the author expressed the opinion, that whilst there was a wide field open to any one who would undertake the investigation of the phenomena connected with the discharge of so large a volume of fresh water as that which pulsated through the Humber to the sea, yet at the outfall there were other forces at work, of sufficient magnitude to throw into shade the effect produced by occasional freshes acting directly upon it.

IV. The relation of the operations of nature and of engineering works to the facts recorded. Broadly stating that the tidal action of the estuary had improved, notwithstanding the encroachments upon its tidal area, the author endeavoured to deduce the cause. He considered that in 867 the area at high water must have been much greater and the depth less than at present, that the south flood tide and the north ebb tide would together produce a sand like the Bull sand, which would accumulate till it became an island, but as the flood channel opened, the ebb channel would become weaker, and would be eventually closed by the shingle from the cliffs of Holderness, and that Spurnhead was in this state in 1250, when Ravenser Odd originated. He believed that the consequent contraction of the entrance, combined with the accretions in the Humber and the repairs of the marsh banks, increased the velocity, raised the high water line of the estuary, and depressed the low water level, and that both Ravenser Odd and Freshmarsh were destroyed by the improved tidal action. The destruction of Ravenser itself was attributed to the advance of the sea upon the Holderness coast, and was supposed to have been accompanied by the outflanking of Spurn Point, which had been destroyed by this means. It was pointed out that the Spurnhead was again an island in 1622, and in turn again became a promontory, as the flood channel travelled southwards, and the ebb channel became closed. It was said that the old action was being repeated at the present time; the Bull sand was the island, but the estuary was now so narrow, and the forces at work in it so great, that it could not rise to the level of low water. It was also said that the sea continued to encroach on Holderness, and would in the present state of things again outflank the Spurn neck.

In conclusion the author stated that the low water channels up to Hull were now comparatively straight and confined, and the action of the ebb tide was therefore better than ever; but that the channels abreast of Spurn were travelling southwards, and the shingle was still endeavouring to close the estuary.

# A DESCRIPTION OF THE LOW WATER BASIN AT BIRKENHEAD.

By Mr. J. Ellacott, M. Inst. C.E.

In this communication a description was given of the plans sanctioned by Parliament in 1844 and in 1853 for the construction of the Low Water Basin, which was intended chiefly as a deep water access, and as a resort and refuge for shipping in the Mersey at all states of the tides. The site fixed on for the Basin was at the mouth of Wallasey Pool, on the Cheshire side of the river, nearly midway between the ferry landing-places of Woodside and Seacombe; and the depth to which it was to be excavated was 20ft. 9in. below the Old Dock Sill, the datum level of the port, or 12ft. 1in. below low-water ordinary spring tides, thereby affording accommodation for vessels of moderate draught at all times. It was proposed to maintain the Basin at its proper depth by the frequent discharge, through sluices, of water from a large dock, or reservoir, called the Great Float, having an area of 150 acres, immediately behind. Allusion was then made to the mode of constructing the sluices, to the views that were expressed with regard to their action, and to the effect that it was anticipated would be produced by the scour through the Basin.

In 1858 the Birkenhead Dock Estate became the property of the Mersey Docks and Harbour Board, and by that body, under the powers of an Act of Parliament obtained in the same year, the Dock Works at Birkenhead, including the Low Water Basin, had since been completed. The Basin, as constructed, was 1750ft. in length, 300ft. in width at the mouth, and 400ft. wide at the extreme end. The area was 14 acres, and the depth 12ft. 4in. below low-water ordinary spring tides. In a recess on the southern side was a landing stage, 1000ft. long, with two bridges leading to the quay. A lock passage, 50ft. in width, formed the water link for vessels between the Basin and the Great Float. By the provisions of the Act, the depth of the Basin was to be maintained by sluices of not less than 800ft. sectional area, communicating with, and drawing water from, the Great Float. The dam within which the sluices and lock entrance at the head of the Basin were built, occupied to a large extent the site of the old channel of Wallasey Pool, consisting of soft and spongy deposit, and the ground had therefore to be piled over nearly the whole of the area, amounting to about 3 acres. A description of the piling was then given, as well as of the means adopted to cut off any sub-communication between the Great Float and the Low Water Basin.

The sluicing arrangements consisted of two chambers, or passages, each 30ft. wide, furnished with gates; the chambers terminating in a system of sluices, ten in number, on each side of the lock entrance. On the outside of the sluices and within the Basin, a stone apron, 80ft. in width, was laid. The leading channel of each sluice was 8ft. in height by 5ft. 2in. in width, giving a sectional area of 41ft. 4in. for each sluice, or a total area for the twenty sluices of 826 feet 8 inches. The sluicing orifices were constructed so as to cause the water to flow from them as nearly in the form of a continuous sheet as a due regard for the stability of the structure would permit. The paddles in the sluices were of greenheart timber, and hydraulic power was applied for the purpose of raising and lowering them. In addition to these sluices two large culverts, each 7ft. high by 6ft. wide, were constructed within the walls on the north and south sides of the Basin. These culverts terminated at the pier-heads in a group of small outlets, and were intended to remove any deposit that might lodge about the wings of the entrance to the Basin.

Reference was then made to the several accidents that had occurred prior to the commencement of, and during the sluicing operations, including the bursting-in of the temporary dam at the mouth of the Basin, and the carrying away of the gates of the 30ft. chambers. The first sluicing trial was at low water of the morning tide on the 20th January 1864, and the last on the 15th November of the same year. The appearance of the Basin while the sluices were in operation was next described. The condition of the water on first leaving the sluices was that of a rushing torrent of white foam. Commencing on one side of the Basin, the lines of direction of the current tended, with a boiling, tumbling motion, towards the opposite side from whence they set out. In their course towards the river, the tendency was to oscillate from side to side, forming for the most part a series of long curved lines. While the main current, increasing in breadth as it approached the river, would be running in a series of bends at the rate of 8 miles and upwards an hour, the intervening portions would be moving slowly and regularly in various directions. Sometimes, at the close of the operations, the current would gradually reverse itself, and finally set into the Basin for a short distance, at an estimated rate varying from half a knot to two knots an hour. Very soon after the sluicing had commenced the colour of the water would be seen to change; a dark brown cloud would rise, and, moving slowly with the rolling mass, would gradually extend itself to the mouth of the Basin and out into the river. It was also observed, that, at a distance of about 150ft. from the head of the Basin, a cross mound of water would rise from 12in. to 18in. higher than the natural level, and would fall off with a long slope on the opposite side, caused apparently by the impetus of the outflowing water driving on, and heaping up the still water with which it had come into sudden contact. The disturbance of the water was very great, and nothing afloat could live in the Basin while the sluices were in operation. On the second occasion of running the sluices, the paddles on the north side had to be promptly closed, on account of the breaking away from her moorings of a wrecked vessel of 1,400 tons, which had been allowed to enter and take the ground in the Basin.

From the sections taken across the Basin after every set of trials, it was soon discovered that a portion of the bottom, immediately beyond the stone apron, was being gradually washed out, and by the 22nd of August a hole 6ft. in depth had thus been formed. All attempts to fill up and reduce this hole, by discharging rubble stone into it, were ineffectual; and after the last trial of the sluices, it was found that the sheet piling in front of the hole was bare on the face to a depth of 4ft., sloping down suddenly to a depth of 9ft. below the finished bottom of the Basin. The piling had also parted from the masonry of the apron, leaving a space between the stone work and the pile-heads of from 3 to 9in.

On the 23rd November the water was pumped out of the north chamber, and an examination shewed that the masonry therein had sustained considerable damage. The side walls and upper portions of the interior were uninjured, but a large quantity of the floor immediately at the back of the sluices had been torn up, and the concrete and pile-heads laid bare in several places. A subsequent examination of the channel leading to the south sluices shewed that similar damage, though not to the same extent, had taken place in the floor of that chamber.

It was stated that, in the interval between the breaking-in of the temporary dam and the commencement of sluicing, a deposit had accumulated over the bottom of the Basin averaging 32in. in thickness, and records were quoted showing the result of the sluicing operations, extending over a period of ten months in 1864, whereby the deposit had been reduced to a thickness of 14in. It was further explained that, in stating the thickness of the deposit remaining after the several trials, no notice was taken of the depth found below the level of 12ft. 4in., which was in some places considerable, especially immediately in front of the apron. Had these extra depths been included, the minimum average thickness of the deposit would have been 4in. only. The quantity of material removed was thus shown to be an amount represented by an average depth over the basin of 28in. One inch in depth contained 1850 cubic yards, and therefore the whole depth of 28in. was equivalent to a total quantity of 51,800 cubic yards. But in addition to this amount, there was also to be taken into account, the daily quantity carried into the Basin by the recurring tides during the forty-three weeks the sluicing operations were continued. An estimate might be formed of this quantity by observing that, from the time of the breaking-in of the dam to the commencement of the sluicing, there was an interval of thirty-one weeks, and during that period the accumulation of deposit was 32in. in depth, representing a total quantity of 59,200 cubic yards. Deducting from this quantity 20,000 cubic yards, which was estimated to have been carried in with the wreck of the dam, there remained a total accumulation of 39,200 cubic yards for the thirty-one weeks, or an average deposit of 1264 cubic yards per week. There was reason to believe that the actual deposit was somewhat greater than this; but assuming it to have been no more, then the total deposit due to the tides for the forty-three weeks would be 54,300 cubic yards, which, added to the original deposit would amount in the whole to a total quantity of 106,100 cubic yards.

The number of times, or days, on which the sluices were run was fifty-six, and the aggregate duration of the operations, including the time occupied in opening and closing the paddles, was 22¾ hours. The largest body of water run out of the Great Float at one time reduced it in depth 5ft. 3in., while the total quantity run off during the ten months was, as nearly as could be ascertained upwards of 8,000,000,000 gallons. Some difficulty was experienced in arriving at the quantity of water run off, owing chiefly to the long oscillating wave that came into play immediately the sluices were closed. The extreme length of the Float was nearly 2 miles, and when once the flow from it commenced, a current was established throughout the whole of its length. The sudden check in the flow, by the closing of the paddles, caused a rise in the water against the wall of the Float nearest the sluices of 12 or 15in. above the previous level, producing the wave which afterwards began to roll back to the farther end of the Float, to return and roll back, again and again, with lessening volume for upwards of an hour until entirely spent.

The form was then given in which the record of the sluicing operations for one month was registered, and for this example, the calculated velocity through the sluices, for the highest and lowest mean heads of water, was stated. It soon became evident, during these operations, that the running of the water was attended not only with much inconvenience and hindrance to business, but that a considerable amount of danger was also incurred. The rapid lowering of the water in the Great Float was highly objectionable. The Basin had to be cleared of vessels when the sluices were to run, and delay arose at times on this account. The injury to the chambers showed the dangerous nature of the operations, for it indicated a tendency to destroy the foundations, and, by forming a sub-communication between the Great Float and the Low Water Basin, to lead to the ultimate destruction of a great portion of the works.

But notwithstanding the numerous drawbacks connected with the system, it was apparent that the sluicing was capable of maintaining the Low Water Basin its proper depth. It was proved to be capable of doing more than that, for at the time the operations commenced a deposit of 32in. in thickness had accumulated, and at the end of ten months, when the scour had operated with more or less regularity through fifteen sets of spring tides, the deposit had been reduced to 14in., leading to the conclusion that, when the primary level had been once reached, a less amount of scouring power would have sufficed to maintain the required depth.

It was, therefore, not on the ground of inability to maintain it at its proper depth, that the closing of the Low Water Basin and its conversion into a Wet Dock was determined on. The principal reasons for adopting this course might be gathered from what had been already stated, and it was not until after much consideration by the Mersey Board, and long negotiations with Railway Companies and other public bodies interested in the welfare of Birkenhead, that the authority of Parliament for the abandonment of this great work was sought and obtained.

After quoting the Act of 1866, authorising the shutting up of the Low Water Basin and its conversion into a Wet Dock, the author remarked that no specific time was mentioned for carrying out the work; meanwhile the Basin was gradually silting up, as soundings taken since the close of the sluicing operations, the last being in November, 1867, gave an average depth over the

Basin of 2ft. 4in. below low-water ordinary spring tides. The average of all depths in November, 1864, when the sluicing operations terminated, was 12ft., and these latest soundings showed that in three years the deposit had increased 9ft. 8in., or at the rate of nearly 39in. per annum, being an average accumulation of about ⅝ of an inch, or 1387 cubic yards, per week.

The total capital expenditure on the Low Water Basin, including the sluicing appliances, the 50ft. lock, and the landing stage, was £470,252. The estimate for inclosing the Basin and forming it into a Wet Dock was £122,000.

The paper concluded with some particulars as to the prevailing winds at Liverpool, and as to the soundings taken at different times in the River Mersey between Liverpool and Birkenhead.

The discussion, which was commenced, was adjourned to the first meeting of the Institution after the recess.

The second paper, which was necessarily read in abstract from the nature of the subject, was "On the present state of Knowledge of the Strength and Resistance of Materials," by M. Jules Gaudard, Civil Engineer, Lausanne.

The author stated, in his introductory remarks, that the theory of the strength and resistance of materials was closely connected with that of molecular mechanics. But being a branch of that science altogether of practical application, it required only to borrow from scientific theories the principles on which to base rules of construction, simple enough to be of general application and yet sufficiently exact to be used with confidence. The formulæ of strength brought into view, on the one hand, the destructive action of external forces, and, on the other hand, the resisting power of the molecules of the material. External forces were of two kinds: one kind comprised elements directly given, such, for example, as weights; the other kind consisted of reactions—functions of given forces. In certain cases these reactions might easily be found by the science of statics alone, as, for example, in the case of a beam placed on two supports; in other cases they would depend on the changes of form of the solid. It was this, for example, which caused the difficulty of calculation in arches and in continuous beams of several spans. Or, lastly, it might happen that the body in question might not be in a state of equilibrium, but that its particles might oscillate under variable dynamic influences, or forces of inertia. This was the case of concussions, vibrations, &c. These various external forces being determined, it would easily be seen if they tended to cause certain parts of the solid to elongate, or to shorten, or to shear, or to turn round certain axes. These various effects, extension, compression, sliding, torsion, flexure, might further manifest themselves separately, or might combine with each other. Under the action of these forces, the body would necessarily be changed in form; for solids perfectly rigid were only pure abstractions. The study of strength, or resistance, had to do with the power which the solid, according to its physical constitution, possessed to maintain, if not its form, at least the cohesion of its parts.

The author then proceeded to consider the forces of various kinds to which materials were subjected, such as extension, compression, sliding, flexure, torsion, and shearing; and in reference to all these, he gave the results and formulæ of the most modern investigations: expressing them at such length as to make them intelligible, but with sufficient conciseness to bring them within reasonable limits of space.

In conclusion, it was remarked that the theory of the strength and resistance of materials touched obscure problems relating to the physical constitution of bodies, and yet its practical character obliged it to be simple. Another motive, also, justified the departure from rigorous exactness, that was, the irregularity of the material facts; if it was good, in effect, to associate mathematical science with physical phenomena, it was incontestable that these two elements, one always logical, the other frequently capricious, were often separated from each other.

In spite, however, of these imperfections, the theory of the strength and resistance of materials in its present state constituted an elegant and useful doctrine, which ought to be better known by the majority of constructing engineers, so much did it tend to impress boldness and elegance on designs of all kinds. In any case the theory, imperfect though it might be, had the great advantage of generalising facts. Empiricism, if left to itself, would encumber the science of construction with a mass of rules, without reason or connection, well calculated to repel and mystify practical men.

It was stated that M. Gaudard's paper would within a short period be printed *in extenso*, and would be distributed among such Members of the Institution as might be interested in the subject, with a view to its discussion early next session.

At the last Monthly Ballot of the Session the following Candidates were balloted for, and declared to be duly elected, Associates, viz.:—Messrs. J. H. Abbey, E. B. Carroll, J. Farrar, F. Garrett, H. N. Garrett, J. Howard, M.P., H. E. Jones, T. Miller, F. Peck, H. M. Simons, and J. Williams.

At the meeting of this Institution on Tuesday, the 4th ult., Mr. Thos. Hawksley, Vice-President, in the Chair, the following candidates were balloted for, and declared to be duly elected, including nine *Members*, viz.:—Mr. Valentine Græme Bell, late Resident Engineer, Mont Cenis Railway; Mr. Valentine Browne, Engineer-in-Chief of the Northern District of the Great Southern and Western Railway of Ireland; Mr. Benjamin Shaw Brundell, Doncaster; Mr. James Buchanan Eads, Engineer of the St. Louis Bridge Company, St. Louis, Missouri, U.S.A.; Mr. Charles Caulfeild Fishe, Resident Engineer of the East and West Junction Railway; Mr. George Fisher, Resident Engineer of the Taff Vale and other Railways, Cardiff; Mr. Ferdinand Wilhelm Weghorst Luders, Chief Engineer of the Copenhagen Harbour Improvements; Mr. Richard Moreland, jun., Old-street, St. Luke's; and Mr. Bernhard Samuelson, M.P., Banbury. Eleven gentlemen were elected *Associates*, viz., Mr. James Clark Bunten, Anderston Foundry Company, Glasgow; Mr. John Collinson, Chief Engineer of the West Wisconsin Railway, U.S.A.; Mr. Edward Gershom Davenport, Westminster; Mr. Albert Chesterfield Jenour, Assistant Engineer, Harbour and Breakwater Works, Table Bay, Cape of Good Hope; Mr. Henry de la Poire Murphy, Nautical Assistant to the Executive Engineer, Bombay Defences; Mr. John Noble, Assistant General Manager of the Midland Railway; Mr. Frank Bailey Passmore, Locomotive Department, Mont Cenis Railway; Mr. Thomas Cheveley Rayner, Sible Hedingham, Essex; Mr. Alfred Terry, Chesterfield; Mr. Alfred Authorn Wickenden, late Locomotive Superintendent of the Great Indian Peninsula Railway; and Mr. John Steddy Winbolt, *M.A.* Assistant Surveyor, Straits Settlements, Malacca.

It was announced that the Council, acting under the provisions of Section IV. of the Bye-Laws, had recently admitted Messrs. Andrew Sherwill Busk, James Doull, and Charles Preston Gibbons, as Students of the Institution.

## INTITUTION OF NAVAL ARCHITECTS.

### THE SHEATHING OF IRON SHIPS WITH COPPER, CONSIDERED AT THE PRESENT STAGE OF OUR EXPERIENCE.

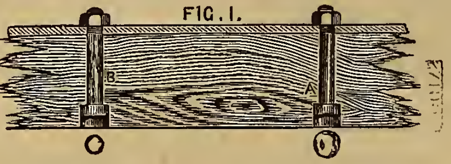
By John Grantham, Esq.

It would have been necessary, under other circumstances, to have offered some apology for bringing before the meetings of this institution a subject which has in various forms already engaged their attention; but many reasons have caused me to tax your patience by again asking you to allow it to come once more under your notice. The subject itself is not attractive, and it requires some courage to present it before such a society as this. The best argument that can be offered for its reconsideration is that, after many years of agitation, the principle now to be referred to is being largely adopted in Her Majesty's navy; and the time which I have been so long and anxiously waiting for has arrived when, not only in the navy, but in the larger vessels of the merchant service, this system will probably receive the attention it deserves.

Happily we are not called on now to give proofs of the tendency of iron ships to foul, or the amount of injury sustained by it. We can afford to give up many things, if necessary, to attain this most important object—freedom from fouling; for instance, in sheathing an iron ship with wood to receive the copper, her beam is increased at least 12in. This, however, is not all loss, as her displacement is increased to a greater extent than the increase in her weight so that she draws less water. But when it is shown, as it can easily be, that the loss of power in an iron ship by the foul condition of the hull is frequently one-half, we see quite enough to induce us to overcome much more serious objections than those which have been brought against sheathing the ship with wood and copper. The two great questions are the tendency of iron ships to become foul, and their liability to be easily pierced when in contact with hard and sharp bodies. So great was even the latter evil, under certain circumstances, that it is said only one of the numerous iron vessels which accompanied the fleet to the Baltic in the Russian war escaped without having a hole knocked in her bottom. The plan which has been recommended, and which is now to be explained for removing one of these evils, is, happily, well suited to remove or ameliorate the other evil. The application of a heavy timber sheathing to carry the copper with which the vessels are to be covered interposes, between the ship and any hard substance with which she may come in contact, an efficient buffer that will no doubt greatly relieve the danger of the plates being penetrated. A history of the leading questions upon which we have based our arguments in favour of this system may be interesting. The magnitude of the evil to iron ships by their tendency to foul became very apparent at least thirty years ago, and both practical men and our leading chemists eagerly sought for remedies, and every principle which has from that time to this been frequently brought forward as a remedy was at the earliest stages fully investigated. Having witnessed these repeated failures, and seeing how much the introduction of large ocean steamers was retarded, I made many experiments to ascertain whether copper could be safely employed as a sheathing for iron ships as it was for timber ones, and I became convinced that this could be done.

The application of copper to iron ships, with the intervention only of some adhesive and non-conducting substance, was practicable, but not efficient; the vessels taking the ground, or the most ordinary abrasion of the surface, would readily displace it, and serious results to the iron plates would be the consequence. I therefore determined to recommend the intervention of a timber sheathing, to which the copper could be nailed in the ordinary manner. My first difficulty was to devise a plan by which the timber could be attached to the ship with safety. Many attempts had been made in the early stages of iron shipbuilding to attach timber planking, bilge logs and false keels, externally to the iron shell, and the difficulty of making sound work was so frequently perceived that I did not venture on its adoption; the effect almost invariably produced was the loosening of the bolts which attached the wood, caused, as I believe, by the unequal action of the two materials when the ship laboured in the sea. Since my attention has been more closely drawn to this subject another source from which many facts could be gleaned has sprung up. About the time when I began to publish my views on this subject, Mr. Jordan, an eminent shipbuilder in Liverpool, built two ships upon a system now publicly known as the composite ship. These are constructed in the following manner:—A complete framework of angle iron is first produced, to which are added externally an iron shear strake, garboard strake, and other longitudinal fastenings, and to these are added in some cases a system of diagonal trussing: a complete frame being thus prepared, timber planking is added, secured to the frame by bolts; these have generally been of iron, sometimes galvanised. Sometimes also Muntz's metal and even copper has been employed; if of iron, great care has been taken to preserve them from corrosion, but with only partial success. The galvanised bolts have corroded the most rapidly, and have been quite abandoned; copper bolts are being used, but not long enough to enable us to judge of the amount of injury to result to the iron framework of the ship ; the expense of copper is also considerable. But it is with iron bolts that we are most concerned, as the points to which we are leading have reference entirely to iron ships. The drawing, Fig. 1, represents two bolts as used to fasten the planks on to a composite ship, and illustrates the way in which the corrosion commences. Sometimes it commences with the head, as at A, and sometimes the body, between the iron frame and the head, is first attacked, as at B, and the head will remain sound. The probable reason for this will be presently shown. Some composite ships have had two sheathings of timber, and the system is said to have advantages. In either case, however, the vessel is finished outside by a sheathing of copper or other metal, as in timber ships.

FIG. I.



The case of the composite ship here cited affords a good basis on which to work out the probable results to a ship built entirely of iron sheathed with wood, and coppered, which, in general terms, is the principle which I early sought to establish ; the great difference being that, as in the composite ship, the planking is secured to the ironwork by bolts only. I substituted an external iron frame rivetted to the plates, so formed as to receive a sheathing of timber, and so firmly wedged as to be secured almost entirely without the use of bolts. On this inner planking is attached, by brass screws, a lighter sheathing of wood, to which the copper is nailed in the usual manner; precautions would, of course, be taken to apply suitable coating between the planks, and the seams would be caulked, so as to render the work as sound as possible. In addition to this one other precaution would be necessary in order absolutely to avoid all possibility of a metallic contact. I proposed the substitution of brass stem and stern-post for those made of iron. It is only necessary to say, that if this system be applied to a new ship, the inner frame would be reduced in weight in proportion as weight is added externally, but one great advantage results from this arrangement : if the principal internal framing be vertical, the external frame may be longitudinal, or if the main internal framing be longitudinal, then the external frame may be vertical. The effect of either plan is that both frames may be attached direct to the shell, and cross each other's path without either being cut into short lengths, as must be the case when both horizontal and vertical frames are attached on the inner side only.

It will now be seen that the composite ship, and the iron ship thus sheathed have many points in common; both are composed of iron frames and plates, both have a timber planking, and both are sheathed with copper. Upon one point, however, there is a striking difference between the two; the planking of the composite ship is necessarily secured to the ironwork by bolts. In the system now described, the security of the planking is made to depend principally on the external framing ; bolts may be used as shown in the drawings, but their explanation under these circumstances will be better given in another place.

The serious question now arises, why have the bolts almost invariably suffered, while the iron framework and plates have been preserved ? The reason in my opinion is quite simple. To a structure made of a hard and incompressible material is attached a shell of a material soft and yielding; the motion given to the ship when labouring in the sea gives rise to an opposing action between these two ill-assorted substances; the bolts which unite them have to sustain the enormous strain thus produced; an imperceptible loosening then takes place, and as the hole enlarges in the timber, water is gradually drawn into the space, and a constant change of water is the result. All this prejudical action would be counteracted were the planking supported by the external frame above described; and the loosening or rubbing motion between the wooden planking and the iron shell, would have no commencement in the latter case as in the former.

It is quite possible that the timber might become saturated with salt water, and the apprehension of this for a long time prevented us from attempting to adopt these systems of sheathing, but I believe the explanations given by Mr. Mallet, when discussing the merits of this question, will be found to be the true ones. Speaking of the system of the external frame he says : "But if the sea water should find its way in, the amount of corrosion that could take place unless there were a stream of water in and out so as constantly to renew the agents of corrosion, would be next to nothing. I have already shown you that if a piece of iron be put into water already robbed of combined air, or if you exclude the air from it, it will not corrode at all. Therefore, if water should get in and lodge behind any one of these blocks of wood, unless it be perpetually renewed by a stream in and a stream out, the water that has got in there will, after a short time, have next to no power in the way of corrosion " It is only necessary to remind you that this "stream in and stream out," is the exact condition which we attribute to bolts, under the circumstances above described, and which no doubt Mr. Mallet would have taken as the explanation of their rapid corrosion. The air which is found in combination with water is the agent by which corrosion is produced, and it does not require that the water should even be salt for oxidation to go on, but this is rendered specially dangerous when the process of oxidation is accelerated by the galvanic action of the copper and iron together with the salt of the sea water. Rob the water of the agent of corrosive oxygen, and the whole is harmless.

Referring again to the drawing of the two bolts, and taking the first example, A, I suppose the rubbing action between the planks and the plates to be going on, the bolt gradually loosening and a slight stream of water being drawn into the bolt hole, in this case finds its way first to the head; the oxidation then commences, and the small quantity of water being deprived of the combined air does no further harm, and if arrested in time the body of the bolt may not have suffered at all, or, in the case of the bolt, B, the water may first find its way to the body, and there the oxygen, being taken up before it reaches the head, has become harmless, and if arrested in time the body of the bolt will alone have suffered : in either case, however, if the process is allowed to go on both the head and the body of the bolt will perish. I respectfully offer these views in explanation of the serious facts above described : others may have sounder theories on the subject, and if so it would add very much to the advancement of this great movement if more correct views were given. There are several instances of copper and other metallic bolts, as before stated, having being substituted for iron ones, but the change in material does not alter the amount of strain to which they are subjected, or the tendency to become loose, and should we be able to prevent corrosion in the bolt we should probably transfer the mischief of corrosion from the bolts to the frames Before concluding this paper, it is but fair to notice some of the objections which have been raised to the external frame; the expense is not one of these, as it is admitted that the cost is less than that of applying bolts. One defect that has been suggested is that the inner planking will not be kept in such close contact with the iron as when bolts are used. I much doubt this, but to meet the supposed defect, I have shown that I do not object to the application of a limited number of bolts, for the simple purpose of drawing the two bodies into closer contact, my objection to bolts being of another character, that of allowing them to be the sole medium through which the enormous strain produced when the ship is working in the sea are to be sustained.

It has also been objected that in extreme cases of injury arising from contact with rocks the framework may be torn away, and the rivets broken, thus admitting the water; the liability to this, in my opinion, is much less than where bolts only are used. A heavy ship beating violently upon the rocks will destroy any work, however strong; but there is one consolation, which is favourable to the plan of sheathing iron ships with copper, arising from the statement made by Mr. Mallet when discussing this subject a few years since at a public meeting. He made a calculation of the amount of injury which would be sustained by an iron ship under the circumstances of the wooden sheathing being violently torn away, and the copper being brought in contact with the iron. He adds : "I would merely say this much, that there certainly would be no such amount of corrosion as to endanger the safety of the ship at sea before she could get home, or into some port where the accident could be repaired . . . . The fact is, that the surfaces of both metals when left to themselves in sea water get coated, more or less, with various insoluble sulphates, and other salts and oxides derived both from the iron and from the sea water, which alter altogether the rate of corrosion that would otherwise take place were chemical action quite unimpeded."

The arguments in favour of adopting some plan for obviating the fouling of iron ships, and the proofs that no such plans have met with sufficient success to make it practicable to employ iron ships of war on foreign stations need not here be repeated as the facts are everywhere avowed. There can be no subject of a practical character more worthy the attention of our institution, and I trust it will receive that consideration its importance deserves.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON THE TEMPERATURE AND ANIMAL LIFE OF THE DEEP SEA

By William B. Carpenter, M.D., V.P.R.S.

The results of recent inquiries into the condition of the abyssal depths of the ocean, tend to prove:—that notwithstanding their apparently profound stillness, undisturbed by the storms which agitate the surface, an incessant motion is everywhere taking place in them, which exerts a most important influence on what would otherwise be the intolerable heat of the Equatorial and the unbearable cold of the Polar regions, and thus affects the distribution of animal and vegetable life, alike on land and in the ocean waters : that the line of demarcation which has been supposed to separate their dreary wastes from the comparatively shallow stratum (300 fathoms) to which life has been affirmed to be restricted, has no real existence; but that whilst the ocean bottom in one region may be as barren as Sahara, it may in another, though at ten times the depth, be teeming with varied forms of organization, that notwithstanding the tremendous pressure exerted by the superincumbent mass (amounting to nearly 3lbs. per square inch of surface for every fathom of depth and thus to 3,000lbs. per square inch at a depth of 1,100 fathoms), animals of the softest conceivable texture can "live and move and have their being" without suffering any inconvenience from the burden, that not even the total privation of light, which the highest authorities have affirmed to be essential to the existence of life,* prevents these rayless depths of ocean from supporting a vast and continuous mass of animal life, which is actively engaged in forming a calcareous deposit over the bed of the Atlantic: a deposit which, when raised above the waters, so as to form dry land, will be designated by the geologist of the future as chalk, and lastly, that in these abyssal depths are preserved in continued existence many types of organization which had been supposed to have long since become extinct; revealing themselves as living denizens of the present epoch, when brought to the surface by the searching dredge of the naturalist, just as the reminiscences of our past lives, stored up in the hidden chambers of our "under soul," are called up in the process of recollection when groped for with the right clue of association.

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* "Organization, sensation, voluntary motion, life," said Lavoisier, "only exist on the surface of the earth, and in places exposed to light. It might indeed be said that the fable of Prometheus was the expression of a philosophical truth which had not escaped the penetration of the ancients. Without light, nature were without life and without soul; a benificent God, in shedding light over creation, strewed the surface of the earth with organization, with sensation, and with thought."—"These words," says Dumas, ('The Chemical and Physiological Balance of Organic Nature,' p. 8), "are as true as they are eloquent."

It had been the good fortune of the speaker to bear a part in these inquiries: a proposal for a deep-sea dredging expedition, which originated with his friend, Professor Wyville Thomson, of Belfast, having been brought by him last June before the President and Council of the Royal Society, and by them strongly recommended to the Admiralty; which, on the strong recommendation of the Hydrographer, assigned for the service the surveying vessel *Lightning*, and provided her with the best appliances that could be got ready on so short a notice. The work of the expedition, which was placed under the scientific charge of the speaker, was specially directed to the exploration of the deep channel which lies between the north of Scotland and the Faroe Islands; and although necessarily limited in time, and much interfered with by bad weather, it afforded results of great interest, in regard both to the physics and the animal life of the ocean depths.

I. The current belief among physical geographers in regard to the temperature of the deep sea had been that it is everywhere 39°; descending towards that point in the Equatorial region, from a surface temperature of between 75° and 85°, in proportion to the depth to which the thermometer is sunk, and falling to 39° at about 1,200 fathoms; whilst it ascends towards that point in the Polar region, as the thermometer sinks through the ice-cold waters nearer the surface, until it rises to 39° at a depth of about 750 fathoms. Between the Equatorial and the Polar regions it has been supposed possible to draw a boundary line at which the temperature of the sea is 39° at all depths; and this line in the Antarctic Ocean, of which the local temperature seems comparatively little disturbed by currents, has been set at 56½° south lat. This doctrine mainly rests upon the temperature-soundings taken in Sir James Ross's expedition; which were not inconsistent with the prevalent belief that sea water like fresh water, has its maximum density at this temperature, and that, consequently, still water at 32° or 33° cannot underlie water at 39°.

Several instances, however, had been recorded, in which temperatures below 39° had been observed; but these were regarded as mere local exceptions, depending upon particular currents. The most remarkable of such observations made by General Sabine more than fifty years ago, in Captain (afterwards Sir John) Ross's arctic voyage was thus chronicled in this journal:—"Having sounded, on September 19, 1818, in 750 fathoms, the registering thermometer was sent down to 680 fathoms, and on coming up the index of greatest cold was at 25¾°. Never having known it lower than 28° in former instances, I was very careful in examining the thermometer, but could discover no other reason for it than the actual coldness of the water." Strange as this record seems, it is by no means incredible; for, as the careful experiments of Despretz have since shown, sea-water, although it ordinarily freezes at 27½°, may be cooled down to 25½° without freezing, if kept free from agitation; whilst, instead of expanding as its temperature falls (which is the case with fresh water below 39°), it continues to contract, so as to acquire its greatest density at 25½°; which temperature, therefore, might be expected to be that of the still depths of Polar seas, when not disturbed by the intrusion of any warmer currents.

Now the *Lightning* temperature-soundings gave a minimum temperature of from 32° to 33·7° through a considerable part of the deep channel (from 500 to 600 fathoms) lying E.N.E. and W.S.W. between the north of Scotland and the Faroe banks, the surface-temperature being about 52°; and it is probable that if there be any error in the observations (all of which rest on the agreement of at least two thermometers), it is that the temperatures were not registered low enough by these thermometers, in consequence of the pressure of 100 atmospheres or more on their bulbs. Though it cannot be positively asserted that these *minima* were the bottom-temperatures of the area in question, this may be considered next to certain, for the following reasons:—1. It is improbable that water at 32° should overlie water at any higher temperature, which is specifically lighter than itself, unless two strata have a motion in different directions sufficiently rapid to be recognizable. 2. The nature of the animal life found on the bottom of this cold area exhibited (as will presently appear) a marked correspondence with its presumed depression of temperature. 3. At a depth of 170 fathoms in the cold area, the minimum was found to be 41.7°; which is just what might be expected at that depth, if the temperature progressively descends with the increase of depth. The positive determination of this question, however, may be expected from the temperature-soundings to be taken this summer; in which means will be adopted for ascertaining the temperature at every 50 or 100 fathoms in the same sounding.

On the other hand, in other parts of the same channel, at the very same depths, and with the same surface surface-temperature (never varying much from 52°), the minimum temperature was never less than 47°; and where this prevailed, not only was animal life far more abundant, but its type was that of the warmer temperate seas.

It does not seem possible to account for the existence of two such very different submarine climates within so short a distance of each other, save on the hypothesis that the water which is 8° or 10° warmer than what may be regarded as the normal temperature of the latitude has come thither from some region nearer the equator, whilst the water which is 6° or 8° colder than the normal temperature of the latitude, has come thither from some region nearer the pole. How far the first of these phenomena is attributable to what is properly called the "Gulf Stream"—that is, to the current of heated water which issues from the Gulf of Mexico, and can be traced for a great distance across the Atlantic, in a N.E. direction—is a matter still open to discussion. But that it is not attributable to surface-drift, seems perfectly clear from the depth to which the excess of warmth extends. And the two facts taken together may with confidence be taken as an example of that continual interchange between the oceanic waters of equatorial and Polar regions, which is as much a physical necessity as that interchange of air which has so large a share in the production of winds. For the water that is cooled in the Polar seas must sink and displace the water that is warmer than itself, pushing it away towards the equator; so that in the deepest parts of the ocean there will be a progressive movement in the equatorial direction; whilst, conversely, the warm water of the tropical sea, being the lighter, will spread itself north and south over the surface of the ocean, and will thus move towards the polar regions, losing its heat as it approaches them, until it is there so much reduced in temperature as to sink to the bottom, and thus return towards its source.

A set of temperature-soundings recently taken across the Arabian Gulf, between Aden and Bombay, by Captain Shortland, in H.M.S. *Hydra*, give a line of bottom-temperature of 33½° Fahr. at depths exceeding 1,800 fathoms, the surface-temperature being 75°. It seems impossible to account for this fact on any other hypothesis than that of a deep current from the Antarctic Polar region, which must have maintained this extremely low temperature throughout the vast course it had to traverse.

II. The collective results of the deep-sea dredgings recently carried on by the Swedish Government under the direction of Professor Sars and his son, by the United States coast survey under the direction of Count Pourtales, and by the *Lightning* expedition under the direction of the speaker, have conclusively established the justice of the inference previously drawn by Dr. Wallich from the more restricted data collected by the sounding apparatus,[*] as to the existence of a varied and abundant submarine Fauna, at depths which have been generally supposed to be either altogether azoic, or tenanted only by animals of very low type. The dredgings obtained in N. lat. 59° 36′ and W. long. 7° 20′, at a depth of 530 fathoms and a minimum temperature of 47½°, included an extraordinary collection of *siliceous sponges* and *Foraminifera*, with *Zoophytes, Echinoderms, Mollusks, Annelids, and Crustaceans;* and among them two specimens of the little *Rhizocrinus* (to be presently noticed more particularly), whose recent discovery by M. Sars on the coast of Norway had furnished a principal "motive" of this expedition. And a single dredging subsequently taken in N. lat. 61° 2′ and W. long. 12° 4′, at the depth of 650 fathoms and a minimum temperature of 46°, gave evidence of the like variety, though the specimens obtained were less numerous and more fragmentary. These two dredgings, it is believed, are by far the deepest that have yet been taken: and the facility with which they were obtained fully justifies the belief that no serious difficulty will be found in the way of the exploration of the ocean bottom by means of the dredge at depths twice as great.

III. The results of the *Lightning* dredgings seem to warrant the conclusion that the distribution of animal life in the deep sea is much more closely related to the temperature of the water than to its *depth*. No contrast could well be more striking than that which presented itself within a distance of 50 miles between the Fauna of the warm and that of the cold area: the former containing, with the animals proper to the locality, a number of forms hitherto known only as inhabitants of the warmer temperate seas; whilst the far more scanty aggregate of the latter consisted to a great extent of animals of a proper *Boreal* type, of which few were met with elsewhere even as far north as the Faroe Islands. And whilst the bottom itself was for the most part composed, in the warm area, of the Globigerina mud, the presence of which (as Dr. Wallich pointed out) seems to go along with the Gulf stream, it consisted in the cold area of stones and sand, the latter including many particles of distinctly volcanic minerals, indicative of a probable derivation from Iceland or Labrador. The comparatively shallow bank in this cold area, at which a temperature of 41·7° was found at a depth of 170 fathoms, presented a Fauna distinctly intermediate between that of the colder and that of the warmer area; the intermixture of the proper Boreal forms being less, and its predominant character being that which might be expected from its geographical position, with which its temperature closely accorded.

IV. The remarkable fact has been ascertained, that two deposits may be taking place within a few miles of each other, *at the same depth and on the same geological horizon* (the area of one penetrating, so to speak, the area of the other), of which the Mineral character and the Fauna are alike different;—that difference being due on the one hand to the direction of the current which has furnished their materials, and on the other to the temperature of the water brought by the current. If the "cold area" were to be raised above the surface, so that the deposit at present in progress upon its bottom should become the subject of examination by some Geologist of the future, he would find this to consist of a barren sandstone, including fragments of older rocks, the scanty Fauna of which would in great degree bear a boreal character; whilst if a portion of the "warm area" were elevated at the same time with the "cold area," the Geologist would be perplexed by the *stratigraphical continuity* with the preceeding of a Cretaceous formation, the production of which entirely depends upon the extensive development of the humblest forms of animal life under the influence of an elevated temperature, and which includes not only an extraordinary abundance of Sponges, but a great variety of other animal remains, several of them belonging to the warmer temperate regions; and he would naturally suppose these widely different climatic conditions to have prevailed at different periods. And yet they have been shown to exist *simultaneously* at *corresponding depths,* over *wide contiguous areas* of the sea-bottom; in virtue solely of the fact that one area is traversed by an equatorial and the other by a Polar current. Further, in the midst of the land formed by the elevation of the "cold area," our Geologist would find a hill some 1,800 feet high, covered with a sandstone continuous with that of the land from which it rises, but rich in remains of animals belonging to a more temperate province; and might easily fall into the mistake of supposing that two such different Faunæ occurring at different levels must indicate two distinct climates separated in time; instead of indicating, as they have been shown to do, two contemporaneous but dissimilar climates, separated only by a few miles horizontally and by 300 fathoms vertically

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[*] The earliest recorded fact of this class still remains one of the most interesting. In the Arctic expedition of Captain Ross, in 1818, a sounding having been taken at a depth of 1,000 fathoms, the line brought up a magnificent *Astrophyton* (then known as *Asterias Caput Medusæ*), which according to the distinct recollection of General Sabine, who was a member of that expedition, must have come from the bottom; since it was partly imbedded in very soft greenish mud into which the heavy deep-sea weight had sunk.

V. But further, the examination of the sample brought up by the 'Lightning' dredgings, of the Fauna of the chalk-like deposit now in progress over the warm area, has shown that it presents many points of most interesting relationship to the fauna of the Cretaceous period. Thus of the Siliceous Sponges which were obtained in such remarkable abundance, some correspond so precisely in structure of the *Ventriculites* of the chalk, that their identity cannot be doubted, although in the process of fossilization the original material of the skeleton has been replaced by carbonate of lime, to be itself applied to the solidification of Sponges of another type in the production of flints.* Again, the speaker stated that he had found the microscopic *Xanthidia,* so common in sections of flint, attached to a filamentous substance entangled in fragments of sponges washed out from the Globigerina-mud. Further, among Mollusca there were two *Terebratulidæ,* of which one at least *(Terebratulina caput-serpentis)* may be certainly identified with a Cretaceous species, whilst the second (*Waldheimia cranium*) may be fairly regarded as representing, if not lineally descended from another of the types of that family so abundant in the chalk. Among *Echinoderms* the most interesting was the little *Rhizocrinus,* that carries us back to the *Apiocrinite* tribe which flourished in the Oolitic period, and which was until lately supposed to have had its last representative in the *Bourgetticrinus* of the chalk, to which the *Rhizocrinus* presents many points of remarkable correspondence.† Among *Zoophytes,* the *Oculina* met with in a living state seems generically allied to a Cretaceous type.

It can scarcely be doubted that a more systematic examination of the remarkable formation at present in progress would place in a still stronger light the intimacy of the relationship of its Fauna to that of the Cretaceous period; and if this view should be confirmed by further inquiry, it would go far to prove, what seems on general grounds highly probable, that the deposit of Globigerina-mud has been going on, over some part or other of the North Atlantic sea-bed, from the Cretaceous epoch to the present time (as there is much reason to think that it did elsewhere in anterior gelogical periods), this mud not merely *a* chalk-formation, but a continuation of *the* chalk-formation; so that *we may be said to be still living in the Cretaceous Epoch.* For, as was pointed out by Professor Wyville Thomson, in the letter which gave occasion to the '*Lightning*' cruise, the oscillations of the earth's crust in the northern portion of the northern hemisphere do not appear to have ranged much above 1000ft. since the commencement of the Tertiary epoch; so that an immense area of the North Atlantic must have been continuously submerged throughout the Tertiary and Quaternary periods; while, for the reasons already mentioned, there must have been a continual movement of the equatorial waters towards the Polar region.

VI. It is obvious that the facts previously stated throw a great light on the changes which Palæontological research proves to have often taken place in the Marine Fauna of any particular area, without any corresponding changes in its own geological condition. For as there must have been deep seas in all geological periods, so there must have been varieties in submarine climate at least as great as those discovered by the *Lightning* temperature-soundings; depending upon those equatorial and polar currents, whose existence has been shown to be a physical necessity. Hence it is obvious that since changes in the direction of such opposing currents must have been produced by any upward or downward movement of the sea-bottom (as in the areas of elevation and subsidence marked out by Mr. Darwin in our existing seas), a considerable modification, or even a complete reversal, of the submarine climates of adjacent areas might have been consequent upon alterations in the contour of the land, or in the level of the sea-bottom, at a great distance—perhaps thousands of miles off.

A renewal and extension of the researches of which the more general results have thus been stated, having been asked for by the council of the Royal Society at the hands of her Majesty's Government, adequate provision has been made by the Admiralty with this object; and H.M. surveying vessel *Porcupine* will be employed during the ensuing season in the prosecution of them, with all the appliances which science and experience can suggest as likely to be serviceable. It may be confidently hoped that, unless the weather should prove exceptionally unfavourable, very important additions will be made by this expedition to our knowledge of the Temperature and Life of the Deep Sea.

The speaker thus concluded:—"The facts I have now brought before you, still more the speculations which I have ventured to connect with them, may seem to unsettle much that has been generally accredited in geological science, and thus to diminish rather than to augment our stock of positive knowledge; but this is the necessary result of the introduction of a new idea into any department of scientific inquiry. Like the flood which tests the security of every foundation that stands in the way of its onward rush, overthrowing the house built only on the sand, but leaving unharmed the edifice which rests secure on the solid rock, so does a new method of research, a new series of facts, or a new application of facts previously known, come to bear with impetuous force on a whole fabric of doctrine, and subject it to an undermining power which nothing can resist, save that which rests on the solid rock of Truth. And it is here that the moral value of scientific study, pursued in a spirit worthy of its elevated aims, pre-eminently shows itself. For, as was grandly said by Schiller* in his admirable contrast between the trader in science and the true philosopher —'New discoveries in the field of its activity which depress the one, enrapture the other. Perhaps they fill a chasm which the growth of his ideas had rendered more wide and unseemly; or they place the last stone, the only one wanting, to the completion of the structure of his ideas. But even should they shiver it into ruins, should a new series of ideas, a new aspect of nature, a newly-discovered law in the physical world, overthrow the whole fabric of his knowledge, *he has always loved truth better than his system,* and gladly will he exchange her old and defective form for a new and fairer one.'"

## LONDON ASSOCIATION OF FOREMEN ENGINEERS.

The monthly meeting took place on Saturday, the 1st ult., at the City Terminus Hotel. It was very numerously attended, and it was gratifying to note the presence of many honorary members who hitherto have not favoured the Association with their company. Mr. J. Newton, of the Mint, president, and Mr. J. Briggs, filled the chair and deputy chair. The election of new members, as usual, constituted the first business of the sitting. Among the honorary associates chosen unanimously on this occasion, were D. Clark, Esq., chief engineer of the Peruvian navy, and Alexander John Dudgeon, jun., Esq.,; Messrs. W. Price and W. Fothergill were elected as ordinary members; and Messrs. F. Jordan, S. Goddard, and T Hooten were nominated as candidates for the same position.

Mr. James Rae next proceeded to read a paper on "Iron Shipbuilding as it Was, Is, and Ought to Be." After modestly acknowledging his inability to place the important subject upon which he intended to dilate, before his listeners in a way commensurate with the requirements of the institution, the author preceeded to say that his remarks would be confined to ships built for peaceful and commercial purposes. Were those vessels constructed so as to ensure the maximum amount of safety to passengers and property? He answered that at present most decidedly they were not. How frequently did it happen that collisions and casualties at sea caused the instant destruction of iron ships and the loss of valuable lives. The reason of these disasters too often laid in the originally defective structures of the vessels. Iron ships, as a rule, were built with frames of that metal, the outer skin being formed of plates of iron and the inner one of timber planking. This latter served as a floor for the reception of the cargo, but it was no safeguard in the event of the outer skin being penetrated. Great stress had sometimes been put upon the efficiency of bulkheads. Practically, they were really of little value. Steamships were usually furnished with four or five. These were supposed to be watertight. Too frequently it was found, in the fell moment of peril, that they were nothing of the kind, and that after a collision it might be said of the vessel that she contained "water, water everywhere," whilst the pumps were incapable of discharging it. Bulkheads were, in ninety-nine cases out of the hundred, illusory and deceptive as protectors of iron ships. Vessels of this kind, as now constructed, were calculated well enough for ordinary service under favourable circumstances, but were totally unfitted to contend against the extraordinary accidents which often befel them at sea. It was quite true that the past twelve years had witnessed great improvements in the construction of iron vessels, both as regarded the quality of the material used and in its mode of application. The author of the paper introduced at this point some startling facts which had come under his own notice when engaged as manager for a large shipbuilding company, and which demonstrated very forcibly the haphazard modes of construction commonly practised not many years since. Mr. Rae also took some credit to himself for remedying the evils to which he referred, and especially considered himself entitled to commendation for having been the first to introduce the plate-planing machine into the shipbuilding yard. This apparatus was now almost universally employed instead of, or as supplementary to, the shearing machine, and Lloyd's rules distinctly specify that all "butts" shall be planed. The economy and excellence of iron ship building had been enhanced in a remarkable degree by the use of the planing machine.

The author next addressed himself to the question of internal defects in the construction of iron ships, and pointed out more particularly the weakness which was formerly observable in regard to the stem and stern. In 1858 he decided to commence an improved system of connecting the stem and stern of vessels entrusted to his building with the kelson. The kelson plate was, in reality, carried up the stem and stern to a considerable height, and the solidity of the vessel was thus increased three-fold. The plan was patented, but, by a legal quibble, the inventor derived no advantage in a pecuniary sense, but, on the contrary, sustained a heavy loss in the shape of costs. The Admiralty had adopted the scheme without recognizing its promoter, and it was now public property, for all who were engaged in iron ship building knew its value and used it as freely as the Government.

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* The mode in which the Silex which furnished the material of flints was first separated from the ocean-waters, has long been an unsolved problem. By Ehrenberg the aid of hypothetical beds of siliceous *Diatoms* and *Polycystina* which were subsequently removed by solution, has been invoked to account for it. But all the examinations which have been made of samples of the Globigerina-mud have indicated that where this great calcareous deposit is taking place, the production of minute siliceous organisms is extremely limited. On the other hand, the vast multiplication of Siliceous Sponges, and the extension of their root-fibres through the Globigerina-mud on the surface of which they grow, furnishes a depôt of silex, which, if re-dissolved, would afford ample material for the solidification of other sponges into flints

† This most remarkable animal, first discovered by M. Sars, near the Loffoden Islands, has been since obtained not only in the '*Lightning*' dredgings; but also by Count Pourtales in the Gulf of Mexico.

* Lecture introductory to a Course on Universal History, delivered at Jena, 1789.

Mr. Rae then proceeded to say that all iron vessels ought to be built with an internal as well as an external iron skin, the latter, of course, being of the greater thickness. Both should be made perfectly watertight. Between the inner and the outer skins a series of bulkheads (say 9ft. apart), and extending from gunwale to gunwale, should be affixed. The spaces between the bulkheads should be filled in with asphalte, so as to prevent water passing from one space to another.

Such an arrangement would add but little to the original cost of the ship, whilst it would increase her strength fully 50 per cent. A ship was, indeed, "a thing of beauty," as well as a valuable minister to the wants of mankind, and it was the duty of an enlightened country like ours to frame stringent laws for governing its construction and thus to promote the safety of those who entrusted their lives to the ocean.

Mr. E. J. Reed, Chief Constructor of the Navy, commenced the discussion which followed the paper, and in doing so said that he agreed with its author as to the generally faulty construction of iron ships as built some few years since. Even now he thought that legislation might be beneficially employed in regard to the construction of iron ships for commercial purposes. He considered that the Admiralty had not acted unfairly towards the reader of the paper. That gentleman had, no doubt, discovered the weak points to which he had referred in regard to the stems and sterns of the older iron ships, but so had many others, and it was hardly to be expected that so self evident an improvement could come under the prohibitory provisions of letters patent.

As to the double skinned vessel with "asphalte" filling between the bulkheads, he had little faith in it. The ship in such case would be permanently loaded very much to her detriment whilst the contingent advantage was problematical. He wishes also to say that in every instance where bulkheads were used in the Royal Navy, their water-tight qualities were tested by hydraulic pressure.

Mr. Wearing combated some of the propositions of Mr. Reed, and considered that the government was rather apt to appropriate the inventions of those who submitted them for consideration. The patent system was, on the whole, good, but it required some modifications.

Mr. Vinicombe defended the Government from the charges made against it.

Mr. Campbell followed in the same direction, and cited cases where compensation had been awarded for valuable communications.

Messrs. Stabler, Taylor, Clark, Ives, Walker, the chairman, and others, continued the discussion, and, finally, a vote of thanks was unanimously awarded to Mr. Rae, who, in returning thanks, took occasion to reply to some of the objections of Mr. Reed and others who had differed with his (Mr. Rae's) propositions. At a late hour the sitting terminated.

## ROYAL GEOGRAPHICAL SOCIETY.

At the usual fortnightly meeting of this society, on April 19th, Sir R. I. Murchison, President, in the chair, the Rev. F. W. Holland gave an account of the recent explorations in the Peninsula of Sinai, made by officers and men of of the Royal Engineers, supported by public subscription, and by several gentleman who had volunteered their services in the work. The principal task undertaken by the party was the survey of a district 15 miles square around Mount Sinai and Jebel Serval, on the scale of six inches to the mile; Mr. Holland, having explored the peninsula on previous occasions on foot, offered his aid as a guide up to the month of February, when he was obliged to return to England. The organization of the expedition was all that could be wished. It was under the command of Captains Wilson and Palmer, and comprised a photographer, naturalist, &c.; an important member of it was Mr. Palmer, of St. John's College, Cambridge, an able Oriental scholar, who was distinguished during the journey by the cognomen of the "Pundit," and who employed himself throughout the survey noting down Arab legends, copying and studying the numerous Rock inscriptions, regarding which he made important discoveries, to be made known on his return to England at the end of May. The expedition arrived at Suez on the 8th of November, and, Arab attendants being prepared beforehand, they were all *en route* for the Desert by the 11th. They kept along the eastern shore of the Gulf of Suez, as far as Wady Ghurundel, and then struck inland for Jebel Musa, which they reached after a march of ten days. Tents were pitched at the foot of Aaron's Hill, all the Arabs dismissed, and the work of the survey immediately commenced. So rugged was the country that it would have been hardly possible to carry the instruments to the more elevated stations, were it not that they were aided by several Arab ibex hunters. The peaks of Ras Sufsafeh, forming the northern portion of Mount Sinai, were the central point of the survey; they rise precipitously from the plain to a height of 2,000ft. In the valleys around and on the slopes the remains of ancient cultivation and reservoirs were continually met with and great numbers of hermits' cells; the whole country, though now a desert, must have formerly been a blooming garden. The party moved to Jebel Serval on the 1st of January. During the survey Mr. Palmer and Mr. Holland copied more than 1,000 Sinaitic inscriptions. The most important fact relating to them was that in several cases the Greek and Sinaitic occurred together, undoubtedly engraved by the same hand, and by means of these Mr. Palmer has been enabled to demonstrate the value of every letter in the Sinaitic alphabet. With regard to authorship, there could be no doubt that they were the work, not of pilgrims, but of a commercial community who inhabited, or at least colonized, the peninsula for the first few centuries of the Christian era. A second paper was on a "Journey across the great Salt Desert from Hanfila to the foot of the Abyssinian Alps," by Mr. Werner Munzinger. This journey, through a previously almost totally unknown country, was performed in June, Mr. Munzinger, our Vice-Consul at Massowah, having been requested to explore this route in anticipation of its being afterwards required for the purpose of the expedition; it proved of no military use, but the observations of Mr. Munzinger revealed to us a region of great interest in its physical geography. A great portion of the area was found to lie below the sea level; this depressed part being separated from the maritime district by a ridge of gypsum, and bounded on the south by the Volcanic Artali range, from the chief peak of which smoke continually issues. The basin contains a large deposit of salt, on which the Abyssinians depend for their whole supply. Between the saline depression and the plateau is a hilly country, traversed by streams which descend from the highlands, but lose themselves in swamps, or become evaporated in the plain. The whole region is peopled by a race which has hitherto been called the Danahil, but this name applies only to a small portion of them. The true name of the country and the language is the Afar. Concerning these singular people, Mr. Munzinger communicated some interesting details. Colonel J. A. Grant spoke on the subject of the paper, and expressed a high opinion of the merits of Mr. Munzinger, and his services to our army. The following new members were elected:—E. C. Bowra, F. J. Galsworthy, C. T. Gardner, and E. J. Leveson.

## MANCHESTER STEAM USERS' ASSOCIATION..

### CHIEF ENGINEERS' MONTHLY REPORT.

At the Ordinary Monthly Meeting of the Executive Committee of this Association, held at the offices, 41, Corporation-street, Manchester, on Tuesday, April 6th, 1869; Hugh Mason, Esq., Vice-President, Ashton-under-Lyne, in the Chair; Mr. L. E. Fletcher, Chief Engineer, presented his report, which was for two months, as at the last monthly meeting the attention of the Committee was taken up by the consideration of the annual report, then in preparation for the general meeting of the subscribers since held on the 9th of March.

"During the past two months 477 visits of inspection have been made, and 1,052 boilers examined: 764 externally, 9 internally, 12 in the flues, and 267 entirely, while, in addition, 11 have been tested by hydraulic pressure. In these boilers 190 defects have been discovered, 7 of them being dangerous. Furnaces out of shape, 6,—1 dangerous; fractures, 35, —2 dangerous; blistered plates, 15; internal corrosion, 38,—1 dangerous; external ditto, 27,—2 dangerous; internal grooving, 14,—1 dangerous; external ditto, 2; water gauges out of order, 9; blow-out apparatus ditto, 8; fusible plugs ditto, 2; safety-valves ditto, 4; pressure gauges ditto, 9; boilers without glass water gauges, 1; without pressure gauges, 1; without blow-out apparatus, 1; without feed back pressure valves, 18.

Tabular Statement of Explosions,
From January 23rd, 1869, to March 26th, 1869, inclusive.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 3 | Jan. 26 | Cylindrical, Flat-ended, Externally fired............ | 1 | 1 | 2 |
| 4 | Jan. 27 | Cylindrical, Camber-ended, Externally fired............ | 0 | 1 | 1 |
| 5 | Feb. 2 | Plain Cylindrical, Egg-ended Externally fired............ | 1 | 4 | 5 |
| 6 | Feb. 12 | Plain Cylindrical, Egg-ended Externally fired............ | 0 | 2 | 2 |
| 7 | Feb. 15 | Single-flue, or Cornish, Internally fired ...... | 0 | 0 | 0 |
| 8 | Feb. 23 | Marine — Particulars not yet fully ascertained...... | 0 | 3 | 3 |
| 9 | Mar. 3 | Particulars not yet fully ascertained.................. | 0 | 2 | 2 |
| 10 | Mar. 9 | Plain Cylindrical, Egg-ended Externally fired............ | 0 | 4 | 4 |
| 11 | Mar. 18 | Single-flue, or Cornish,...... Internally fired ...... | 0 | 0 | 0 |
| | | Total.............. | 2 | 17 | 19 |

"During the last two months nine explosions have occurred, killing two persons and injuring seventeen others. Not one of the boilers in question was under the inspection of this Association."

The last Ordinary Monthly Meeting of the Executive Committee of this Association was held on Tuesday, April 27th, 1869, when Mr. L. E. Fletcher, Chief Engineer, presented his report, of which the following is an abstract:—

"During the past month 221 visits of inspection have been made, and 489 boilers examined: 279 externally, 7 internally, 6 in the flues, and 197 entirely, while, in addition, 1 has been tested by hydraulic pressure. In these boilers 143 defects have been discovered, 7 of them being dangerous. Furnaces out of shape, 10; fractures, 30,—2 dangerous; blistered plates, 11,—1 dangerous; internal corrosion, 22; external ditto, 22,—3 dangerous; internal grooving, 21,—1 dangerous; external ditto, 4; water gauges out of order, 7; blow-out apparatus ditto, 6; fusible plugs ditto, 2; pressure gauges ditto, 4; boilers without pressure gauges, 1; without feed back pressure valves, 3.

"During the stoppage of the mills at Easter, advantage was taken of the opportunity for making as many internal and flue examinations as possible of the boilers enrolled, the engineering staff engaged in the office turning out to assist the inspectors in getting inside the boilers and up the flues. In this way a large number of entire examinations was made, and a great many of the members were accommodated. The whole number of these entire examinations, however, does not appear in the above list, as a portion was included in last month's return.

"The defects met with were not generally of a novel character, so that only one of them merits remark on the present occasion. This was a case of fracture which occurred to a blow-out elbow pipe from its being tightly bound in the brickwork setting, when the movement of the boiler, consequent either on its settlement or the expansion of the parts, broke it in two. This occurred when the boiler was in work, and fortunately was shortly discovered by the difficulty experienced in keeping up the water level.

"The objection to binding blow-out elbow pipes in the brickwork has been frequently alluded to on previous occasions. The cross wall should be recessed so that the elbow pipe may be quite free; and thus unaffected by the movement of the boiler, be less exposed to corrosion, and at the same time open to view. This arrangement should be attended to in laying down all new boilers, while there is very little difficulty in introducing it in those already set.

"EXPLOSIONS.

"On the present occasion I have to report three explosions, by which five persons were killed and six others injured. The scene of the catastrophe has been visited in two cases by officers of this Association, and details of the explosions will be found below. In the other case full particulars have not yet been received, but I hope shortly to be in possession of them. Not one of the explosions occurred to boilers under the inspection of this Association. The following is the monthly tabular statement:—

TABULAR STATEMENT OF EXPLOSIONS,

From March 27th, to April 23rd, 1969, inclusive.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 12 | April 1 | Portable Agricultural, Locomotive, Internally fired............ | 1 | 4 | 5 |
| 13 | April 11 | Single-flue, or Cornish, Internally fired ............ | 0 | 0 | 0 |
| 14 | April 19 | Portable Vertical, Internally fired ............ | 4 | 2 | 6 |
| | | Total.................. | 5 | 6 | 11 |

"No. 12 explosion occurred at two o'clock on the afternoon of Thursday, April 1st, to the boiler of a portable agricultural steam-engine engaged in thrashing out a rick of barley at a farm-yard, and resulted in the death of one person as well as in injury to four others.

"The boiler, which was of the multitubular locomotive type, measured 8ft. 6in. in length and 2ft. 4in. in diameter in the barrel or cylindrical portion of the shell, while the thickness of the plates was five-sixteenths of an inch, and the load on the safety-valve 50lb.

"The boiler gave way in the outer shell, which was completely destroyed, being rent from the inner casing of the fire-box, torn up into a number of small pieces, and scattered in every direction, one to a distance of 90 yards, another to 100 yards, while the smoke-box door was thrown to a distance of 150 yards. On the occurrence of the explosion the son of the proprietor, who was close to the engine at the time, was killed on the spot; while another man standing by him is reported to have been blown up into the air as high as one of the adjoining stacks, while three others were scalded.

"The evidence given at the inquest with regard to the cause of the explosion was of the most unsatisfactory character. The engineer from a neighbouring iron-works, called in by the coroner to investigate and report, stated that he found the boiler ripped from end to end, the parts thrown about in every direction, and four of the small flue tubes collapsed and rent. He attributed the explosion to shortness of water, considering that the flue tubes had been rent from overheating, when some of the water escaping from the boiler had come in contact with the heated metal, and produced sufficient pressure to cause the explosion. It must be clear on the face of it that this evidence is absurd. It is manifestly impossible for the escape of water from the flue tubes in a multitubular boiler to create an explosion of the shell. If any pressure at all were generated thereby, and this is more than improbable, and quite unknown in practice, it would be within the fire-box, and not in the shell; whereas it was the shell of the boiler which was torn in pieces, while the fire-box with its nest of tubes, though hurled to a considerable distance, was comparatively unhurt. Added to this, the rent flue tubes formed the bottom row, while the upper ones, which would be the first to be injured by shortness of water remained sound. The fractures in the flue tubes were simply the result of the explosion, and in no way connected with the cause; and may well be accounted for by the fact, that the fire-box, with the tubes attached to it, had been thrown over the thrashing machine, and to a distance of 25 yards. Besides this, the crown of the fire-box was uninjured, though it would have suffered from overheating before the flue tubes, while a slight coating of incrustation about one thirty-second of an inch thick remained upon it, which overheating would have cracked off, so that it is clear the explosion was not due to shortness of water.

"The simple cause of the explosion was the malconstruction of the boiler. The manhole was not strengthened, as it should have been, with a substantial cast-iron mouthpiece, through the neglect of which so many explosions have from time to time occurred, the particulars of which have been given in these monthly reports. From this unguarded manhole, which was placed at the crown of the outer casing of the fire-box, the primary rent sprung, which, developing in various directions, ripped the shell into fragments. The cover of this manhole was of the dangerous internal class, illustrated in the Association's Monthly Report for August, 1867, being carried by a couple of bridges, from each of which two bolts were suspended. An attempt had been made to strengthen the manhole by an external wrought-iron ring, half-an-inch in thickness and one inch in width; but this was attached to the shell by four five-eighths' rivets only, while the heads inside the boiler were nearly gone. In consequence of leakage from this joint, the plate, originally five-sixteenths of an inch in thickness, was so eaten away that only one-sixteenth of an inch remained. Had this manhole been strengthened by a suitable cast-iron mouthpiece, in accordance with the explanation and sketch given in the Association's Report for October, 1866, the leakage at the cover would not have occurred, and thus the plate would not have been eaten away by corrosion, while at the same time the parts would have been strengthened and the explosion prevented.

"When the causes of explosion are so simple, their results so fatal, and their occurrence so frequent, it is time that some action was taken to secure common sense investigations into these matters. At present boiler-makers can palm off on the public bad boilers, and steam users employ them with the certainty that when they explode with fatal consequences they will, by the help of a coroner and his jury, be publicly absolved from all responsibility, and the event proclaimed, as it was in this case, to be 'accidental.'

"No. 14 Explosion, which was of a very fatal character, occurred about four o'clock on the afternoon of Monday, April 19th, to the boiler of a portable steam crane employed on a jetty in unloading barges. On the occurrence of the explosion, the shell of the boiler was thrown into the river, and the fire-box to a distance of about 25 yards inland, where it lay a little above high-water mark on the edge of the river, while the crane was shattered to pieces, four men killed, and two others injured.

"An officer from this Association visited the scene of the catastrophe very promptly after the explosion had occurred; but as it was high tide at the time of his visit, he was unable to see the shell, which was only visible at low water, so that I wait a report of further visits for full particulars. He was informed, however, that the exploded boiler was in every respect similar to another alongside employed in the same service, from which it would appear that it was of vertical construction, internally fired; that it measured about 8ft. 6in. in height, 4ft. 6in. in diameter, and three-eighths of an inch in the thickness of the plate, the pressure at which it was worked being 40lb. per square inch.

"With regard to the cause of the explosion, the old story of overheating of the plates through shortness of water has been freely circulated; but this may be at once contradicted, as the fire-box was found to be as perfect as the day it was set to work, and showed no signs whatever of overheating. It would be premature to give a positive opinion as to the cause of this explosion until the shell can be further examined; but this opportunity may be taken of pointing out that this boiler, like the one just referred to under the head of No. 12 Explosion, was not strengthened at the manhole as it should have been by a substantial cast-iron mouthpiece, while from the direction in which the fragments flew, which affords generally a very clear indication of the position of the primary rents, there appear to be grounds to suspect that the boiler first gave way at the unguarded manhole. But whether this be so or not, the fact of the manhole being unguarded was a dangerous omission, and no boiler is safe under such circumstances, and can only be worked at the risk of the lives of those near it. The adjoining boiler, already referred to, should not be worked another day without having the manhole guarded, or the gang of men around it may at any moment be blown to pieces, as has so frequently occurred in other cases. It is hoped that this warning will be of some avail, and that future reports will not have to include the slaughter of several more poor fellows through the neglect of the precaution of a substantial cast-iron mouthpiece.

### "Memorial to the Home Secretary on the Unsatisfactory Investigations at present conducted by Coroners with regard to fatal Boiler Explosions.

"It will be remembered that, at the last Annual General Meeting of the members of this Association, as well as at the previous one, attention was called to the unsatisfactory character of the inquiries conducted by coroners with regard to fatal boiler explosions, and to the erroneous verdicts returned; while it was shown how important it was that this evil should be corrected and sound information disseminated in every case, in order to check the loss of life and suffering at present recurring week by week, and at the same time render unnecessary any further Governmental action which might prove an interference with the freedom of the steam user. With this view unanimous resolutions were passed at both of these meetings, requesting the Committee of Management to take such steps as they might find necessary to secure these investigations being rendered more satisfactory, so that the truth might be fully arrived at and plainly spoken in every case.

"To bring the subject before the attention of the public, a paper with regard to it was read at the Annual Meeting of the British Association for the Advancement of Science, held in Norwich in September last; and at the Annual General Meeting of the Steam Users' Association, held on the 9th of March, it was proposed that the attention of the Government should now be drawn to the subject, and that a deputation should wait upon the Home Secretary with a memorial.

"No time was lost in carrying out this proposition. At the following meeting of the Executive Committee, held on the 6th instant, a memorial was submitted for approval, discussed, and adopted; and Thomas Bazley, Esq., M.P. for Manchester, at once communicated with, and his assistance in the matter requested. With this Mr. Bazley very kindly and promptly complied; and through his good offices a deputation of the Manchester Steam Users' Association had an interview with the Right Hon. Henry Austin Bruce, Her Majesty's Secretary of State for the Home Department, on Friday, April 16th. Unfortunately, through a sudden and severe attack of illness, the President, William Fairbairn, Esq., C.E., F.R.S., LL.D., &c., was unable to accompany the deputation, which consisted of three of the Vice-Presidents—Thomas Bazley, Esq., M.P., Manchester; Hugh Mason, Esq., Ashton-under-Lyne; and John Penn, Esq., C.E., F.R.S., Greenwich. Also of John Lancaster, Esq., M.P., Wigan, and Thomas Schofield, Esq., Manchester, members of the Executive Committee; as well as of John Hick, Esq., M.P., Bolton, Corresponding Member, and Mr. L. E. Fletcher, Chief Engineer.

"Mr. Bazley, in introducing the deputation to the Home Secretary, briefly called attention to the serious loss of life and suffering entailed by steam-boiler explosions. This, he wished to point out, was preventible; and to explain that, it was the wish of the memorialists that coroners should be empowered and instructed to command the attendance of eminent engineers to give evidence when conducting inquiries in consequence of these sad disasters, so that light might be thrown on the subject, and greater care induced; by which means it was thought that the loss of life and property now occurring would be much lessened, if not altogether prevented. In order to give some idea of the serious nature of a boiler explosion, Mr. Bazley laid before Mr. Bruce some photographic views of the scenes of these catastrophes, showing the havoc and desolation occasioned, and concluded by presenting Mr. Bruce with the memorial, of which the following is a copy:—

"To the Right Hon. Henry Austin Bruce, Her Majesty's Secretary
of State for the Home Department.

"The Memorial of the Manchester Steam Users' Association for the Prevention of Steam-Boiler Explosions, and for the Attainment of Economy in the Application of Steam.

"Sheweth,—That your memorialists have for several years observed with considerable pain, the great sacrifice of human life arising from the frequent occurrence of steam-boiler explosions, while they have at the same time observed the unsatisfactory character of the inquiries conducted by coroners with regard to these sad catastrophes; in consequence of which the opportunity is lost of disseminating valuable information with regard to them, and thus of doing much to prevent their recurrence, so that these fatal disasters go on week after week unchecked.

"The results of steam-boiler explosions are most serious. As many as twenty-nine persons have been killed by a single explosion: and it is by no means infrequent for ten or twelve lives to be sacrificed by one such catastrophe, and several able-bodied men to be seriously injured in addition. Since the formation of this Association in 1854, it has recorded the occurrence in different parts of the kingdom of as many as 490 explosions, by which 832 persons were killed and 971 others injured. This, however, is by no means the whole number of lives sacrificed, as, in the earlier years of the Association's operations, such complete records were not obtained of all the explosions occurring throughout the United Kingdom as is now the case, so that many escaped its notice. It may be stated that, at the present time, nearly fifty explosions occur on an average every year, killing from sixty to seventy persons, and injuring as many others. Many of the persons killed and injured are bread-winners, so that not only do they suffer, but a great many others are rendered more or less destitute.

"The number of persons killed every year by boiler explosions exceeds the number of passengers killed on all the railways throughout the United Kingdom. From the return published by the Board of Trade, it appears that during the last six years 123 passengers were killed, while during the same period 390 persons were killed by boiler explosions: the annual average of lives lost being from twenty to twenty-one in the case of railway passengers, and of sixty-five in consequence of boiler explosions. Thus it will be seen that for every passenger who loses his life by railway traveling three persons are killed by boiler explosions.

"From the foregoing it will be seen, that the annual loss of life from steam-boiler explosions, and the great amount of suffering and destitution entailed, which falls upon a class who are unable to protect themselves, is a subject demanding immediate attention.

"The Manchester Steam Users' Association for the Prevention of Steam-boiler Explosions has, during the last fourteen years, carried out amongst its members a system of voluntary periodical steam-boiler inspection. This is found fully adequate to the prevention of explosions, and not a single boiler ever guaranteed by this Association has exploded. In addition to inspecting the boilers of its members, it has sent its engineer to visit the scene of most of the boiler explosions occurring throughout the country, in order to acquire full particulars, and arrive at the cause of the catastrophe. These constant investigations have shown that much unnecessary mystery has been attached to the subject of steam-boiler explosions, and that they all arise from the simplest causes, and could readily be prevented. AS A RULE, BOILERS BURST SIMPLY BECAUSE THEY ARE BAD. Bad either from original malconstruction, or bad from the effects of hard work and old age. In a word, the cause of every boiler explosion is NEGLECT, and the preventive simply CARE.

"At the inquiries, however, conducted by coroners, the truth is seldom arrived at and seldom spoken. The most frivolous and one-sided evidence is accepted. The explosions are stated to be wrapt in mystery, and to be altogether unaccountable; or they are attributed to terrestrial magnetism, to the formation of explosive gases, to the accumulation of wind in the pipes, to atmospheric influences, or other purely whimsical and imaginary causes, while a verdict of 'accidental death' is almost universally brought in; though the simple truth of the matter very frequently is, that the boiler has been worked on till worn away to the thickness of a sheet of paper, when it has exploded from simple exhaustion. Too frequently, in the case of explosions resulting entirely from commercial greed, the blame which should have been borne by the boiler-maker or boiler owner, is cast on the boiler attendant, who has either been killed by the explosion, or, if alive, is too poor or too ignorant to defend himself, in consequence of which the poor fellow, who has had a narrow escape of his life through working his master's bad boiler, is sent to gaol on a charge of manslaughter. Thus the inquiries at present conducted by coroners consequent on boiler explosions are eminently unsatisfactory, and very serious consequences, as well as much injustice, result therefrom.

"It is not, however, intended by these remarks to cast any reflection upon coroners' inquests as an *institution*. On the contrary, it is thought that a considerable public service would be rendered if advantage was taken of the coroner's inquiry for arriving at the cause of every fatal boiler explosion, and of plainly stating the truth, while, by these means alone, much would be done towards the prevention of these fatal catastrophes. It is, however, desired strongly to call attention to the insufficiency of the coroners' investigations in connection with steam-boiler explosions as at *present conducted*, which it is thought is due, in a great measure, to the rapid growth of steam-power, while it is also desired to point out how the difficulty may be met.

"The plan that your memorialists venture to recommend for adoption is simply that every coroner should be both *impowered and instructed*, when conducting an inquiry consequent on a fatal steam-boiler explosion, to avail himself of the assistance of two competent engineers, having no connection with the works at which the explosion occurred. These engineers to visit the scene of the catastrophe, investigate the cause of the explosion, and report to the coroner thereon; their reports—which might be either joint or several, as found most convenient in each case—to be accompanied with explanatory scaled drawings, showing the original construction of the boiler, and, as far as possible, the lines of rent, as well as the direction in which the fragments were thrown, and the distances at which they fell. The engineers to attend the inquest, and assist the coroner in his examination of witnesses, as well as to give evidence themselves before the jury. Further, in order to secure to the public the full advantage of the investigation, the engineers' reports, with the accompanying drawings, to be printed and deposited in the Patent Office, and to lie there for inspection and purchase, as in the case of specifications of inventions. Also copies of these reports to be forwarded to the members of both Houses of Parliament, as in the case of reports on railway accidents.

"By the adoption of such a course, a mass of most valuable information would shortly be accumulated; and in addition to this, and which is of the utmost importance, the responsibility of every steam-boiler explosion would be attributed to the right party. This, it is confidently hoped, would render any further Governmental action unnecessary, and very shortly put down steam-boiler explosions simply by the force of truthful investigation and plain speaking.

"The fact is not lost sight of that many coroners have already the power, of which, in some cases, they avail themselves, of remunerating competent scientific witnesses, and which proves of considerable public service; but such is not the case in every instance, and coroners, to whom the plan proposed in this memorial has been mentioned, have stated that it would prove of considerable assistance to them in conducting their investigations on such technical subjects as boiler explosions, and that they should be glad to see it brought into operation.

"Your memorialists, therefore, earnestly pray that such steps may be taken as may be necessary for carrying out the plan suggested above, for rendering the investigations of coroners consequent on steam-boiler explosions more searching, and the verdicts more truthful and plain speaking than they are at present; considering that, by this simple measure, much would be done to prevent the occurrence of these sad catastrophes, and towards the saving of the lives of those who, as a rule, are too poor, too friendless, and too ignorant to protect themselves."

## BLACKFRIARS BRIDGE.

This magnificent structure is fast approaching completion, and is expected to be opened about the end of this month. The works were begun in June, 1864—that is to say, the old bridge was closed at that time. It took 18 months to remove that ruinous dilapidation, and it was not till the January of 1866 that the present structure was commenced. It has thus taken three years and a half to complete it from first to last. Old Blackfriars was commenced in 1760, and finished in 1769, Vauxhall-bridge was begun in 1811 and finished in 1816, Waterloo-bridge was also begun in 1811 and finished on the 18th of June, 1817, the second anniversary of Waterloo, after which victory the bridge was called; Southwark-bridge took six years to build, Hungerford five years, old Westminster 11, and new Westminster, from one cause or another, very nearly the same time. London-bridge took seven years before it was completed. So that if we get Blackfriars-bridge in three years and a half from its commencement, we shall have no cause to complain of its engineers, or of the speed with which the contractors have done their work under them.

As far as regards the structure, the new bridge may be said to be absolutely complete. All the iron ribs of the arches are bedded and bolted together. These arches of wrought iron were, of course, built in separate ribs, but were not laid on the stonework of the piers, and rested entirely on the timber centering, with their ends about three-quarters of an inch from the stone piers, from which they were wedged up. These wedges have now been knocked out, and the arches allowed to settle down into their places on the stone. No bed plates were used, but between the iron and the stonework molten lead was run in, and when this had hardened, the wedges were knocked away, the iron ribs at once came to their proper bearings, and in no instance was any perceptible deflection observed when the arches were thus left to carry their own weight. The centering under the arches has now, therefore, not an ounce to support, and is simply retained in its place for the accommodation of the painters who are about to paint the whole structure. The ironwork has already had two coats of paint, the last which is now to be given to it is one of a rich bronze green. The outer iron spandrils of the arches are covered at the intersections of the lattice work with large ornamental bosses, much after the pattern of the well-known heraldic Rose. These decorations are to be richly gilt, and the colour contrasts which will be afforded by the gilding, the bronze green, the red polished granite, and the white carved stonework will make this bridge, as seen from the river, one of the most beautiful works of its kind. Every one of the granite columns have now been fixed. They are the largest ever used in any bridge. Each of them cost more than £800, for they are nearly 24ft. in circumference, and have been polished to the smoothness of an agate surface. Each column stands on a richly-carved pediment of white Portland stone, and each is surmounted by a most massive capital carved in birds, flowers, and sea and river weeds. Four of these capitals have been finished by Mr. Phillips, and their effect is really splendid. The other four are well in hand, and will, it is hoped, be ready when the bridge is opened. Above these capitals will be placed the carved recesses. There are to be four of these on each side of the bridge, so that the somewhat bare and monotonous outline of parapet at Westminster is avoided. Each of these eight recesses are to be 10ft. deep by 13ft. wide. They will be fitted with plain granite benches, but the outer, or river, side will be carved with quatre-foils deeply cut, but not pierced through. In such a hghly ornamental structure as this is to be, it is satisfactory to know that the lampposts are to be as artistically treated in form an ornamentation as the rest of the work. These standards are not to be fixed on the parapet, as has always been the case hitherto, but will be in close lines along the curb at each side, so as to throw the greatest amount of light over the broad pavements and over the still broader roadway for the use both of the vehicles and pedestrians. Lamps, as they have until now been placed, lose half their light in the gloom of the river. In each of the recesses, however, branched lamps will be placed as beacons to warn the passing river traffic by night where the sharp-edged piers are. A double row of lights like this will certainly be necessary on a bridge where the footways are 15ft. broad and the roadway nearly 50ft. About two-fifths of the whole bridge have already been paved with its buckle-plates. It will take upwards of a million rivets to rivet them all, and sufficient has been done to form a fair path across the whole bridge, while the two shore arches are quite finished. Each of these arches on the Surrey and Middlesex side have a span of no less than 155ft., and these are the smallest in the structure, though they are 3ft. wider than the central arch of London-bridge, which was at the time considered the largest arch ever attempted. The largest arch of old Blackfriars-bridge had only a span of 100ft. The centre arch of the new bridge has a span of 185ft.

The abutments on the Surrey side have now been quite finished. These are noble monuments of stone work. They rise with the solidity of the old Egyptian temples, and with a massiveness that is really grand. They are each surmounted with bold, splendidly-carved cornices, and when seen at low water, rising to a height of nearly 60ft. from the shore, they have a most imposing effect. A broad square stone platform is left on their summits, on which it is hoped that the Corporation will place groups of statuary, either in bronze or stone, though the former, of course, would be more in keeping with the general character and colour of the bridge. Nearly all the ornamental parapet-work has been delivered at the bridge, but only a few short lengths have been placed in position. It is a very beautiful specimen of Venetian Gothic in its most florid style, and does great credit to the founders. From the inside of the bridge this parapet will appear rather low, being only 3ft. 6in. in height. From the river, however, it will look bold and sufficiently lofty, as it will stand on the summit of a rich cornice. The work of taking down the scaffolding has been already commenced in some parts, and in others the piles around parts of the structure will be drawn. There are altogether nearly 6,000 loads of this timber to be removed above and below water, but it is calculated that all may be got away within a couple of months. Directly the new bridge is opened the work of pulling down the temporary wooden one alongside it will be proceeded with. This temporary bridge remains as strong as ever. It is, in fact, a temporary bridge only in name, for, with repairs to piles now and then, it would last as long almost as old Black-friars-bridge, which for nearly half the time that it stood was in a state of chronic dilapidation and decay. The new bridge will cost altogether about £320,000, or at the rate of about £4 the superficial foot. At this rate it will be one of the cheapest permanent bridges yet built in London.

## ROUTES TO INDIA.

An interesting report has been made by Captain Tyler, of the Board of Trade, on the facilities afforded for communication with the East by the railway of the Brenner Pass and the harbour of Brindisi, which he has recently re-inspected. He describes at length the improvements made in the harbour, and says:—While it is true that the excavations have not been pushed forward during the last three years with much energy, it must be admitted, on the other hand, that the Italian Government have not received, in consequence of the want of more regular and rapid communication with Brindisi, much encouragement to induce them, in the straitened condition of their finances, to spend more money in a shorter time. One of the principal objects which they have in view, in improving this harbour, is to prepare it for the passage of an Indian mail, and thus to obtain its recognition as a point of departure from Europe for the East; and they have done much in that direction: all the various requirements indicated in my report of 1866, with the exception of a dock, having been taken in hand, or having made more or less of progress. . . . These arrangements, and the works generally remaining to be completed, would, no doubt, be expedited if there were any immediate prospect of the employment of the harbour for the regular Indian mail steamers, and the proposed dock would in that case be very necessary. The works of the Suez Canal have of late made so much progress that the hope may now, perhaps, be indulged of seeing it prepared at no very distant date for the passage of ocean steamers, and, in that event, of contemplating the running of steamers direct from Brindisi to Bombay, by which the inconvenience and expense for mails and passengers of transhipment on either side of the Isthmus would be avoided." Captain Tyler took the opportunity of visiting the port of Monopoli, 44 miles from Brindisi, and comes to the conclusion that, considering all the circumstances, Monopoli cannot be considered as a rival port with Brindisi for the accommodation of steamers of a large class, and for the main purposes of Eastern communication; though it will have, when the contemplated works are carried out, great advantages for the traffic and commerce of the district, as it has already for local residence. He next describes the railway journey, and the construction of the line and carriages. The Brenner Railway, he remarks, "is of the most interesting character. It is 16·61 Austrian, or about 76 English miles in length; and it rises from a height of 829½ Austrian feet above the sea at Botzen, to 1,793 at Brixen, and 4,325 at the summit of the Pass, descending again to a height of 1,831·46 feet above the sea at the Innspruck station. The steepest gradient on the ascent from Botzen to Brenner is 22·5 per 1,000, or 1 in 44·4; but there is almost a continuous descent from Brenner to Innspruck of 1 in 40. The sharpest curves have radii of 900 feet against 600 feet for the Sommering Pass. The longest bridge, over the Eisack, near Mauls, between Freienfeld and Grassi, has a span of 130ft.

The whole of the works have been constructed in the most substantial manner, and for a double line of rails, which will be laid when the traffic is sufficient to require them. . . . For the passenger traffic, six-wheel coupled engines are used, with wheels 4ft. in diameter, with 18in. cylinders and 24 in. of stroke, and weighing 40 tons each. They take 90 tons of load up 1 in 40. The wrought-iron break-blocks on their tenders are found to lose a tenth of a pound for every 200 Austrian miles run. The system of continuous breaks on the carriages, which has been found to answer so well on some of the railways of this country, has not yet been adopted on the Brenner Railway, the ordinary practice being to employ separate breaks on half the vehicles in each passenger train, and on one-fourth of the vehicles in each goods train. But the guards and breaksmen can each apply two breaks, the break vehicles being placed with their cabs and break handles next to each other. The running speed, ascending and descending, is about 27 kilometres per hour, and the drivers are permitted, when then they are behind time, to increase their speed by one-fifth in ascending, and by one-tenth in descending. . . . This railway across the Alps, though it passes over so great an elevation, and through so difficult and romantic a district, has, thanks to the skill of the engineer, nothing exceptional about it to prevent it being worked much in the same way, and with the same means and appliances, as any other railway. The steepest gradients, 1 in 40, are not more severe than those on the Sommering Pass, over the Ghauts for the Great Indian Peninsular Railway, or on the Giovi incline in Italy, and are not indeed so severe as some which are constantly worked with heavy traffic in this country, such as the line between Dowlais and Brecon, with 6¾ miles of 1 in 39, the Lickey incline of 1 in 37 near Bromsgrove, or the Folkestone Harbour incline of 1 in 30, or the Oldham incline of 1 in 27. The time from London to Alexandria is put at 150 hours. It is proposed to have carriages with accommodation for sleeping, for refreshments, for through circulation in the carriages, and for all things necessary on the journey.

Captain Tyler adds:—"The routes *via* Marseilles, *via* the Mount Cenis, and *via* the Brenner may appear to be rivals to one another, and, as regards the two latter, for a through traffic yet to be increased or even created. But regular means of communication will infallibly bring to each of them passengers and goods on which, as yet, we do not calculate. Having regard to the interests involved, to the population and the countries, to the commodities to be exchanged, there can be no doubt, in pursuance of all previous railway experience, that offering, in apparent competition with one another, increased facilities, they will, by facilitating additional travelling, increasing knowledge, and inducing commerce, contribute to the advancement rather than to the detriment of one another. There will in time be enough passing between the great East and the busy West to support more than three lines of through communication. . . . These routes will however, themselves be only provisional, pending the advance of railway communication through the south-east of Europe and through the west of Asia. The lines by Constantinople and the Euphrates Valley, and over the Greek frontier to Cape Sunium, so near to the Suez Canal, have yet in process of time to be constructed; and the hope of the Indian traveller of the next generation, chimerical as it may appear to many at present, must be nothing less than to pass dryshod from London to Bombay—through a submarine tunnel from Dover to Calais—through Europe by railway—over the Bosphorus by a bridge; and forward by railway down the Euphrates Valley and round the Persian Gulf to Bombay."

## CORRESPONDENCE.

*We cannot hold ourselves responsible for the opinions of our Correspondents.*

### INDIAN CANALS.

*To the Editor of* THE ARTIZAN.

SIR,—In an article in THE ARTIZAN, of the 1st May, you quote a report from "The Englishman's Overland Mail," 9th March, 1869, in which it is stated that during the khureef, or autumn crop, 446,000 acres were irrigated last hot season, and you estimate that the probable area during the cold season would be 669,000 acres more, or in all 1,679 square miles.

Now your estimate of the probable area for the cold season appears to me much too low; for, though it is nearly correct for the Eastern Jumna Canal, it must be much too small for the Ganges Canal, as the following abstract will show:—

AASTRACT FROM REVENUE RETURNS OF CANALS IN THE NORTH WESTERN PROVINCES. SHOWING THE AREAS IRRIGATED DURING THE UNDERMENTIONED YEARS.

| OFFICIAL YEARS. | Ganges Canal. | | REMARKS. | Eastern Jumna Canal. | | REMARKS. |
|---|---|---|---|---|---|---|
| | Area in square miles irrigated during hot season. | Area in square miles irrigated during the cold season. | | Area in square miles irrigated during hot season. | Area in square miles irrigated during the cold season. | |
| 1860–61 | 108.4 | 427.4 | The year of famine. | 179.5 | 228.8 | The year of famine. |
| 1861–62 | 121.1 | 460.5 | ... ... ... | 69.5 | 155.3 | ... ... |
| 1862–63 | 141.7 | 179.5 | Accident to Canal. | ... | ... | No Official returns of areas published. |
| 1863–64 | 152.4 | 550.4 | ... ... ... | ... | ... | |
| 1864–65 | 230.8 | 654.1 | ... ... ... | 68.8 | 49.0 | Rates raised.* |
| 1865–66 | 116.3 | 566.7 | Rates raised.* | 78.3 | 78.2 | ... ... |
| Totals. | 879·7 | 2,838·6 | | 396.1 | 511·3 | |

From the above it appears that on the Ganges Canal the area irrigated during the Rubbee, or cold season, is nearly 3¼ times greater than what is watered during the khureef, or hot season, while on the older canal, the Eastern Jumna Canal, the area irrigated during the khureef is rather more than ¾ of what is watered during the rubbee or cold weather crops.

The general proportion for both canals is that the area watered during the cold season is nearly 2⅔ times greater than what is irrigated during the hot weather; but, as the season now gone by has been an abnormal one, probably a much greater proportional area has been irrigated by these canals during the last summer than has been during the cold weather just now past. To be within safe limits, therefore, judging by the above abstract, I think we may safely calculate that twice as great an area was watered during the rubbee than the khureef. This would give an area of 892,000 acres instead of 669,000 for the rubbee; that is 348 square miles require to be added to your estimate, which in round numbers would run the total up to rather over 2,000 square miles. So, taking your other figures as correct, the probable number of human beings fed by the waters of these two canals in all would amount to no less than 2⅔ millions of human beings, many of whom must have perished but for these two canals during the past year of drought. Yours, etc.,

Canal.

## REVIEWS AND NOTICES OF NEW BOOKS.

*The Carpenter and Joiner, and Elements of Hand-Railing.* By Robert Riddell. Revised edition. Philadelphia: Claxton, Remsen, and Haffelfinger. London: Atchley and Co., 106, Great Russell-street, W.C.

Since the time of Peter Nicholson, no work of equal value and completeness has been published for the use of the practical carpenter, joiner, and staircase hand. The descriptive text, like the illustrations given in the thirty odd plates, is so excellent and intelligible, that but little study is required to comprehend perfectly the particular subject matter under treatment.

We cannot too strongly express our approval of the work for its practical merits. The style in which the book is got up is highly creditable to the printer and publishers, and altogether it is the best work of the kind which has heretofore issued from the press in England or America.

*Iron; its History, Properties, and Processes of Manufacture.* By William Fairbairn, C.E., LL.D., &c. Third edition. Edinburgh: Adam and Charles Black.

This valuable work, the first and second editions of which have already been fully noticed in the columns of The Artizan, has now reached its third edition. The progress in the manufacture of iron, or rather in the manufacture of that species of iron variously called steel, "steel iron," "homogeneous iron," &c., has been so great during the last few years that new editions of works, professing to treat thereon, are constantly necessary to keep pace with such improvements. Thus, since the last edition of Mr. Fairbairn's treatise, the improvements there predicted, only four years ago, have become accomplished facts, while fresh processes have sprung up claiming to effect still greater improvements, both in the quality and price of this material.

The accurate and comprehensive tables of experiments upon various qualities of steel obtained from different manufacturers, which appear at the end of this new edition, will be found especially valuable to engineers and others who are contemplating a more extended use of steel in the construction of large buildings.

*The Industries of Scotland; their rise, progress, and present condition.* By David Bremner. Edinburgh: Adam and Charles Black.

A work professing to describe the industries of the most industrious people in the world would naturally be expected to be either interesting or valuable. In the present instance that expectation is fully gratified, as Mr. Bremner's book may be safely said to be both valuable and interesting. The subjects upon which the author treats are, of course, very numerous; beginning with the most important—coal-mining—he passes on, by an easy transition, to the scarcely less important industry—the manufacture of iron, and from this, of course, to manufactures in iron. Besides these natural productions of the country, almost every industry that has attained to importance in Scotland is graphically and cleverly described, such as shipbuilding, railways, coachmaking, manufactures of plate, jewellery, and various metals, woollen and cotton manufactures, calico printing and dying, sewed muslin, fishing-nets, paper-hangings, floorcloth, leather, india-rubber, glass, paraffin, and others too numerous to mention. These various articles appeared originally in the columns of the weekly issue of the *Scotsman* newspaper—a paper justly noted for its enterprising management. They have now been collected together, and form a handsome octavo volume, the original text having been subjected to careful revision, numerous additions made, and, where it was considered essential, the latest statistics given.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

During a late extraordinary freshet in the Hudson the water in the State dam opposite. Troy rose 21ft. above high-water mark, and by its enormous pressure carried away 200ft. of the top of the dam. This injury will seriously affect navigation on the Champlain Lake.

Advices from Alexandria state that the Egyptian Government have just made an arrangement with the Suez Canal Company which puts an end to every anterior and future claim, on the payment to the company of £1,260,000 in Government securities.

The San Francisco Mechanics' Institute will open its Seventh Annual Exhibition next September, in a building covering 70,000ft. of ground, and erected specially for the purpose at a cost of 45,000 dols.

A new gum has been introduced into the trade, obtained from trees in New Zealand; it is called kouric, and has been found to be a most excellent strong and water-proof cement for caulking tanks, and cementing pieces of glass, stone, or wood together. Before using, it is fused and mixed with one third part of its weight of castor-oil.

Manufacture of Safes in Victoria.—Large premises have been fitted up in this colony for the manufacture of colonial safes, which are actually stated, by a colonial paper, to be superior to those of English make. There is a large demand for them in the colony, and it is said they can be made 20 per cent. cheaper than the English article.

Cultivation of Sugar in Queensland.—In the cultivation of the sugar-cane the great drawback hitherto has been the probable difficulty of getting it crushed, but this difficulty, when fairly taken in hand, appears to be vanishing quickly, and we hear of the breadth of land under sugar being increased on all sides. The initiation of small machinery, although not so economically worked as mills of greater power and capability, will go far towards dissipating those groundless fears which have hitherto had possession of the farmers' minds. Information of the successful working of these mills will be hailed with great satisfaction by many who, while unable to procure the expensive machinery heretofore considered necessary, may be able to procure an arrangement costing about one-tenth of the amount. There are already two mills worked by horse-power, and two other mills are to be erected in time for next season's crop, both of much larger size than those previously mentioned, and to be worked by steam-power. In every district in the colony where agriculture is carried on, the breadth under sugar is increasing, so fully satisfied are those interested that the success of sugar cultivation is a certainty. The cost of manufacturing has been £5 7s. 6d. per ton, including cutting, carting and shipment. Other machinery of moderate steam-power is shortly expected, and it will be of the most perfect description, and include all the latest improvements. That it will be the evident necessity of every planter of twenty acres and upwards to supply himself with a mill is certain, for the distance between the various plantations will, in most cases, be considerable, and the heavy carriage an insurmountable difficulty; but there are many other reasons besides the cost of carriage to induce the planter to bend all his energies to the procuring of machinery for manufacturing his own crop, notwithstanding that theorists, and even some practical men, have declared in favour of large contract factories.

The departure of the German expedition to the North Pole is fixed for the 7th of this month. The *Germania* and the steamer *Harmonia* will proceed direct to the Island Jan-Mazen, and then go northward, and endeavour to discover an opening in the ice between the 74th and 76th degrees of latitude. If by the end of August the expedition should not have succeeded, the vessels will go and pass the winter either at Spitzbergen or at Gilsland, and resume the enterprise in 1870.

### LAUNCHES.

Messrs. A. and J. Inglis, launched from their yard at Point House, on the Clyde, 10th ult., a screw-steamer named the *Mallet*, built to the order of Messrs. Baring Brothers and Co., and intended for the China coasting and river traffic. Immediately after being launched she was towed to a crane berth to receive her machinery, which is supplied by the same firm.

On Monday, the 8th ult., there was launched from the shipbuilding yard of John Elder, Esq., at Fairfield, Govan, an iron screw steamship of 1,478 tons builders' measurement. As she left the ways she was gracefully christened the *Benin*, by Miss Campbell, daughter of Duncan Campbell, Esq., of London. The *Benin* has been built to the order of the African Steamship Company, and will form one of their line to the west coast of Africa. Her engines are of 200-horse power nominal, and are constructed on Mr. Elder's patent compound principle.

### TELEGRAPHIC ENGINEERING.

Telegraphs in the Mediterranean.—The Mediterranean Extension Telegraph Company (Limited) have notified that their Corfu office has just been connected with Santa Maura by a telegraph cable laid by Messrs. Newall and Co., of Gateshead, and it is expected the other Greek islands will be joined in a few days. These islands will be connected with Athens, and by a cable to Syra, the chief port in the Levant.

A company has been organized, with the capital subscribed, to construct a telegraph line from St. Louis, through Texas, to the Pacific coast. Some of the parties were recently in Washington to perfect the arrangement.

### STEAM SHIPPING.

Steam to Japan.—The Peninsular and Oriental Steam Navigation Company have announced an accelerated mail communication with Japan. Their steamers will henceforth run fortnightly from Hongkong to Yokohama and *vice versa* direct, instead of *via* Shanghai, as heretofore. The Hongkong and Shanghai mail service will be continued as at present. The gain by this arrangement will be five days on the homeward passage and two days on the outward passage.

The passages of the *Somersetshire*, which has just arrived from Melbourne, were sixty days out and sixty days home. She was coated for the first time with Messrs. Lamont and M'Innes's compositions, and the results were awaited with some interest.

A number of yachts are being built on the Atlantic coast for prominent American citizens.

### NAVAL ENGINEERING.

Naval Economy.—The Parliamentary Committee of Inquiry of last year, presided over by Mr. Seely, has already resulted in greater efficiency and economy in dockyard. management. We trust, therefore, that Mr. Seely will shortly follow up his own recommendation—viz., "that *further inquiry* should be instituted into the question whether the money now spent upon building ships is employed on the *most efficient* and economical class of ironclads.'

### DOCKS, HARBOURS, BRIDGES.

The New Graving Dock at Greenock.—The Greenock Harbour Trustees recently held a special meeting for the purpose of considering a report by Mr. Kinipple, C.E. regarding the plans and dimensions of the proposed graving dock at Garvel Park. Provost Morton presided and moved, that the Trust, having considered the plans of Mr. Kinipple authorise the New Works Committee to instruct him to prepare detailed plans and specifications of the minimum dimensions stated in his report, viz.: 500ft. clear length of floor; 60ft. coping width of entrance; 20ft. water on sill at spring tides; 80ft. inside breadth, within copings, the committee to report to the Trust the precise site recommended, and the cost of the whole works as ascertained by tenders. An amendment was proposed that the width and depth should be less than those proposed by the Provost, but the motion was carried by fourteen votes to four in favour of the amendment. The estimated expense of the dock, as proposed, is £76,940; of which £59,250 is for the dock, £8,300 for breastworks, £4,890 for channel, and £4,500 for boiler and engine.

## SHIPBUILDING.

Yacht for the Prince of Wales.—Messrs. Harvey have launched a screw steam yacht of 40 tons for his Royal Highness the Prince of Wales. The dimensions of the yacht, which has been named the *Princess*, are as follows: Length between perpendiculars, 68ft.; length over all, 78ft.; breadth, 11ft.; height in cabins, 6ft. 4in.; draught of water, 5ft. 6in. The engines; of 12-horse power, are now being fitted by Messrs. J. Penn and Son, of Greenwich. The yacht will be ready for sea in about three weeks.

## APPLIED CHEMISTRY.

The Substitution of Alum-shale for Bone-Black in Sugar Manufacture.—M. Belin proposes to do away with the use of animal charcoal for sugar manufacturing purposes, and to substitute instead the exhausted alum-shale after it has been applied to the manufacture of alum, or sulphate of iron. 100 parts of juice from beet-root require from one to eight parts of the exhausted shale. The liquid, after having become clarified, is evaporated to 26 degrees Beaumé in contact with air without any previous filtration, and next concentrated in vacuum pans to 43 degrees. The concentrated syrup thus obtained is run into large iron tanks and left to crystallise. The only advantage gained by this process is, beside the saving of animal charcoal, the obtaining of molasses better fit for the distillery of spirits.

Bleaching Paper Pulp.—M. Gauny proposes to bleach paper pulp by means of bichromate of potassa. For 100 kilos. of pulp (supposed to be dry) he uses 50 kilos. of bichromate and 150 kilos. of hydrochloric acid, mixed with a sufficient quantity of water to make the pulp float. After twelve hours' standing, the chloride of chromium is washed out by means of clean water, and the pulp treated with a small quantity of bleaching powder to make it thoroughly white. The chloride of chromium is precipitated by means of excess of lime, and this mixture calcined in a reverberatory furnace where it is converted into chromate of calcium.

Rhicolene.—Considerable quantities of this highly volatile liquid are now being manufactured for commercial uses. It is the lightest of all known liquids, and in many respects is a very remarkable substance. Its specific gravity is 0·625. It is so volatile that a small portion poured upon the warm palm of the hand produces a hissing sound, very similar to pouring water upon hot iron; it almost instantly vanishes into vapour. It has so little odour that an ounce of it evaporated in a close room will scarcely be noticed. It is manufactured in Boston, and put up in packages of from one pound to five gallons each.

A black copying ink, which flows easily from the pen and will enable any one to obtain very sharp copies without the aid of a press, can be prepared in the following manner:—One ounce of coarsely broken extract of logwood and two drachms of crystallized carbonate of soda are placed in a porcelain capsule with eight ounces of distilled water, and heated until the solution is of a deep red color, and all the extract is dissolved. The capsule is then taken from the fire. Stir well into the mixture one ounce of glycerine of a specific gravity of 1·25, fifteen grains of neutral chromate of potash, dissolved in a little water, and two drachms of finely pulverized gum arabic, which may be previously dissolved in a little hot water so as to produce a mucilaginous solution. The ink is now complete and ready for use. In well-closed bottles it may be kept for a long time without getting mouldy, and, however old it may be, will allow copies of writing to be taken without the aid of a press. It does not attack steel pens. This ink cannot be used with a copying press. Its impression is taken on thin moistened copying paper, at the back of which is placed a sheet of writing paper.

Carbolic acid may be deodorized by mixing it in a crystallized form with twice its weight of gum camphor, and adding whiting to the compound. In this form it is said to be valuable both as a disinfectant and as a protection to furs against moths.

## RAILWAYS.

The Strathalbyn and Middleton Railway was opened for traffic on Tuesday, February 23. His Excellency, with a distinguished and numerous party from Adelaide, was present, and the demonstration was carried through with the greatest *éclat*. The line is 21 miles long, and, for the present, horse traction is to be used upon it. The total cost has been £104,000.

The trains between Paris and Florence are accelerated, and a gain of eleven hours in the journey is the result.

The jury empanelled to inquire into the Thirsk accident recommend the immediate adoption, by the North Eastern Company, of locking signals, to the absence of which the accident seems due.

One of Messrs. Aveling and Porter's engines is now in use by the Cape Copper Mining Company. The following account of the trial is extracted from the *Cape Argus*:—"The trial trip from this place to Springbok was made on the 19th inst., the engine leaving Ookiep early in the afternoon, ascending with ease the steep gradient at the toll-gate, passing through the village to the reduction works, and returning to Ookiep the next day. On the following Tuesday, under the management of Mr. H. Morshead, the Company's resident engineer, a more severe trial was made, the engine, in the presence of the Company's superintendent, ascending a steep hill on the Nababeep-road, the path being in places very rocky and cut up by water-courses. In returning to Ookiep, the old wagon road was taken, in which a deep "sluit" was met with. This also was easily crossed. The engine seemed, in fact, able to make its way almost anywhere that an ox-wagon could be driven, and it will doubtless render valuable assistance in the transport of ores and materials.

A railroad tie, of polished California laurel, mounted on each end with solid silver, accompanied by a spike of solid gold, costing 200dols. was forwarded from San Francisco, on the 4th ult. to the end of the Central Pacific Railroad. It is the last tie, and was to be laid by Leland Sanford, on the 8th ult., thus completing the Pacific Railroad.

## ACCIDENTS.

No fewer than fourteen large locomotives have exploded within the past seven months in the United States, killing twenty-nine persons outright and severely wounding a much greater number.

On the 26th of April the steamer *St. Elmo* exploded her boilers in Mobile Bay, Alabama, killing one of her officers and seriously injuring six other persons.

On the morning of April 24 the steamer *Uselda*, while coming down the Missouri river, struck a snag near Sioux City, and began to sink. As she was gradually sinking, the water rose around the boilers, and they suddenly exploded, shattering the boat to pieces and killing and wounding a large number of passengers. Fifty have been burnt to death or drowned, and as many more injured. There was a large number of United States soldiers on board, who were coming down from the various military posts among the Indian tribes from the Upper Missouri.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 76 | 0 | 0 | ,, | ,, | ,, |
| Tough cake and tile do. | 74 | 0 | 0 | ,, | ,, | ,, |
| Sheathing and sheets do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bolts do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 80 | 0 | 0 | ,, | ,, | ,, |
| Old (exchange) do. | 63 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 76 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7 | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6½ | 0 | 0 | 6¾ |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 0 | 0 | 20 | 5 | 0 |
| Do. to arrive | 20 | 5 | 0 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | ,, | ,, | ,, |
| TIN. | | | | | | |
| English blocks, per ton | 127 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 128 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 133 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 134 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 132 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 8 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 14 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 7 | 0 | 1 | 8 | 0 |
| IX. do. 2nd quality do. | 1 | 13 | 0 | 1 | 14 | 0 |
| C. Coke do. | 1 | 4 | 0 | 1 | 6 | 0 |
| X. do. do | 1 | 10 | 0 | 1 | 12 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 15 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 15 | 0 | ,, | ,, | ,, |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 12 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 0 | 0 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | 6 | 5 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 15 | 0 | 7 | 10 | 0 |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 11 | 6 | 2 | 19 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 5 | 0 |
| Do. in faggots do. | 15 | 5 | 0 | 16 | 10 | 0 |
| English spring do. | 19 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 5 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 12 | 6 | 19 | 15 | 0 |
| Do. W.B. do. | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 15 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 15 | 0 | ,, | ,, | ,, |

* At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

### DATED APRIL 19th, 1869.

1191 A. Smith—Ornamenting hats
1192 R. Chapman—Railway fish plates
1193 J. Horsley—Blasting powder
1194 H. A. Bonneville—Rims of hats
1195 P. Bourchart—Raising beer, &c.
1196 W. H. Smith—Lavatories, &c.
1197 H. Aitken—Treating iron ores
1198 J. E. Ward—Hats
1199 A. V. Newton—Friction matches
1200 H. Y. D. Scott—Pottery kilns
1201 S. Shaw—Feed water apparatus

### DATED APRIL 20th, 1869.

1202 L. Goetz—Cleansing wool
1203 A. Brady—Producing pure iron direct from crude iron ore
1204 F. W. Follows and J. Bata—Sweeping carpets, &c.
1205 N. Wilson—Sewing machines
1206 F. Bartels—Dressing tin ores
1207 R. J. Ellis and C. L. W. Fitzgerald—Drying animal matters
1208 R. C. Rapier—Railway signals
1209 W. E. Gedge—Water meter
1210 K. S. Mackenzie—Fences
1211 H. Lee—Looms
1212 G. Green—Separating ores
1213 W. R. Lake—Improved toy
1214 M. Andrew—Vessels for containing oil or other liquids, &c.
1215 W. R. Lake—Lamps

### DATED APRIL 21st, 1869.

1216 W. F. Reynolds and J. A. Mays—Velocipedes
1217 W. Holloway—Manufacture of beverages from cocoa nibs
1218 J., J., and W. Fletcher—Lubricating the wheels of velocipedes
1219 P. R. Hodge—Cloth, &c.
1220 E. O. Catrin—Key to act as a cock at the upper part of bottles
1221 B. Picard—Towing, &c.
1222 J. W. McCarter—Improvements in condensers for steam engines
1223 T. C. Bull—Boots
1224 M. Henry—Phosphate of lime
1225 H. C. Mayer—Velocipedes
1226 M. Pletts—Oil feeders
1227 C. D. Abel—Mural paintings
1228 C. M. Barker—Steam generators
1229 W. Johnson—Communication between passengers, &c., of a train
1230 C. E. Brooman—Dressing fabrics
1231 W. Robinson—Sheets of steel, &c.
1232 J. H. A. Bleckmann—Firearms
1233 J. Francis, J. Donaldson, and G. Reavely—Locking apparatus

### DATED APRIL 22nd, 1869.

1234 J. Holding—Looms
1235 G. Dania, J., T., R., and S. Stott—Carding engines
1236 H. T. Lewis and W. White—Sash frames
1237 J. Eccles—Lessing warps
1238 G. White—Ship weir
1239 W. Catchpool—Treatment of hay
1240 J. C. Ridley—Treating waste rails, &c.
1241 M. Hillary—Harrows
1242 G. G. Tandy—Carburetting air
1243 A. Borgnet—Composition
1244 A. Borgnet—Paint
1245 W. R. Lake—Locks
1246 W. R. Lake—Communication between the passengers, &c., of a train

### DATED APRIL 23rd, 1869.

1247 W. Palliser and T. English—Screw bolts, bolt holes, &c.
1248 N. Wilson—Velocipedes
1249 G. White—Motive power
1250 W. A. Little—Voltaic batteries
1251 G. T. Bousfield—Sheep washing apparatus
1252 S. Smith—Axle, &c.
1253 W. B. Dick—Extinguishing fires
1254 J. Whittaker—Moulding wheels
1255 H. E. Newton—Preventing the bursting of steam boilers
1256 H. E. Newton—Puddling iron
1257 T. Wilson—Cartridges
1258 E. Tatham—Construction of levers
1259 E. M. Reilly—Explosive bullets

### DATED APRIL 24th, 1869.

1260 J. Major, W. Wright, and G. H. Jones—White lead
1261 J. Thompson—Working machinery to any required power without fuel
1262 H. Reed—Pneumatic apparatus
1263 A. Muir—Stocks and dies
1264 J. and B. Weigel—Shirt studs
1265 R. Foster—Crushing and pulverising
1266 J. Head—Harrows
1267 S. Brooke—Carding wool
1268 J. Crabtree—Cutting shives, &c.
1269 C. D. Abel—Velocipedes
1270 P. Jensen—Sewing machines
1271 D. A. S. Macintosh—Cask spile
1272 A. Jack—Reaping machines
1273 A. Clark—Reaping machines
1274 J. Codbird—Motive power machinery
275 O. Engholm—Preserving food, &c
1276 O. Engholm—Retaining caught fish in life for market
1277 J. Scharr—Liquid soap
1278 T. Forster and T. B. Cow—Compounds containing india rubber, &c.
1279 W. R. Lake—Axle boxes

### DATED APRIL 26th, 1869.

1280 G. White—Carding tow
1281 I. Farrell and W. Turner—Velocipedes
1282 A. Watson—Sleeve links
1283 J. Cunningham—Cutting sandwiches
1284 H. Hall—Obtaining motive power
1285 J. K. Broadbent and S. and J. Prestwich—Furnaces
1286 J. Smith—Signal apparatus
1287 A. V. Newton—Reversible parasol
1288 W. E. Newton—Steam generators
1289 R. Sterne—Anchors
1290 S. Oakman—Smelting furnaces
1291 G. Hawxhurst and J. Pollock—Preventing the corrosion of steam boilers
1292 W. Prowett—Knitting machines

### DATED APRIL 27th, 1869.

1293 W. R. Lake—Locks
1294 J. P. Cooper—Nuts and bolts
1295 B. Dobson—Carding engines
1296 Hon. R. Flower and M. Crowly—Organs
1297 J. Cane—Cases for fusees
1298 J. H. Sams—Sowing machines
1299 J. Anderson—Velocipedes
1300 R. Marshall—Wheels
1301 H. W. Hart—Ovens
1302 T. Aspden and E. H. Lambert—Boots and shoes
1303 J. H. Simpson—Propulsion of trains

### DATED APRIL 28th, 1869.

1304 O. Moseley—Smoking pipes
1305 T. A. Haberkorn and B. Rudolph—Sewing machines
1306 I. J. J. Lewis—Ventilation of hats
1307 J. B. Kroll and A. Froment—Percolators
1308 G. Heyes—Winding yarns
1309 N. Voice—Cask stands
1310 H. A. Bonneville—Concentrating the caloric of heated water
1311 J. Pim—Ventilating apartments, &c.
1312 L. Isaac—Folding tables
1313 E. Cooper—Ventilating hats
1314 T. Bostock—Boots and shoes
1315 R. B. Forbes—Rigging vessels
1316 J. Frolich—Generating gas
1317 A. Meredith—Iron and steel
1318 D. Greig, R. Burton, J. Gozney, and T. Atkinson—Cultivating land
1319 W. E. Gedge—Pianofortes
1320 H. Bray and H. Adams—Improvements in graining
1321 W. R. Lake—Generating steam

### DATED APRIL 29th, 1869.

1322 M. Wilkin and J. Clark—Radiating the axles of railway carriages
1323 R. Griffith—Velocipedes, &c.
1324 O. Rose—Steam engines
1325 J. G. F. Blow and W. Blow—Driving bands for machinery
1326 E. Crowe—Applying waste heat

### DATED APRIL 30th 1869.

1327 R. Elsdon—Kilns for the manufacture of lime and cement, &c.
1328 W. Spence—Manufacture of felt
1329 J. Broadfoot—Lavatories
1330 J. Jamieson and T. Holt—Steam engines
1331 F. Jackson and T. Corbett—Lubricators for steam engines
1332 F. Bujeaud—Bottle envelopes
1333 A. Sleigh—Motive power
1334 R. F. Bigot—Level with mirror
1335 J. R. Jefferies—Horse rakes
1336 H. J. Seeis—Harrows
1337 R. Craig—Manufacture of paper
1338 R. Ward—Oven for baking, &c.
1339 E. Tutte—Hollow walls
1340 J. Smith—Communication between the passengers of railway trains, &c.

### DATED MAY 1st, 1869.

1341 T. Greenwood—Cutting joints for boxes, &c.
1342 J. Mackie—Breech loading firearms
1343 J. Wilson—Bobbins
1344 W. B. Robbins—Hand pumps
1345 E. and T. Waltham—Engines to run on common roads
1346 J. P. Balm and R. Newton—Worsted spinning frames
1347 J. B. Blake—Velocipedes
1348 G. Ritchie—Stop hinges
1349 W. Broughton and T. Steven—Cooking range
1350 J. Conway—Forge fires
1351 R. Saunders—Cable stoppers

### DATED MAY 3rd, 1869

1352 C. T. Liernur—Inodorous removal of human excrements
1353 P. Barry—Printing machine
1354 J. Shackleton—Utilising exhaust steam
1355 S. H. Hodges—Heels for boots, &c.
1356 H. Williams—Velocipedes
1357 J. B. Nimmo—Lever compensation door and gate spring
1358 B. Hunt—Spinning hemp, &c.
1359 D. P. Wright and C. Butler—Lamps
1360 F. W. Kasclowski—Separating the woody part from the fibre of flax
1361 P. Southern—Furnaces

### DATED MAY 4th, 1869.

1362 W. Seed—Furnaces
1363 E. Thomas, E. Thomas, and J. Morris—New agricultural implement
1364 C. Topham—Mincing meat, &c.
1365 R. Wuppenstein—Registering passengers in omnibuses, &c.
1366 T. Cockcroft—Window sashes
1367 J. Bullough—Warping machines
1368 R. Fennelly—Cases for the conveyance of fresh meat
1369 T. Perkins—Reaping machines
1370 W. E. Gedge—Gas apparatus for raising liquids
1371 A. and E. Fau—Washing skins
1372 J. Tall and A. Williams—Bending, &c., metallic sheets
1373 A. V. Newton—Wheels
1374 W. E. Newton—Engines to be used as motors or pumps
1375 A. C. F. Franklin and E. Dubois—Improvements in gas engines

### DATED MAY 5th, 1869.

1376 T. Sibley—Velocipedes
1377 D. Adamson—Portable steam engines
1378 J. P. Kent—Mortising machines
1379 G. Clark—Cartridges
1380 W. Mackean—Cattle food
1381 E. H. Richmond—Preserving meat, &c.
1382 A. Cocke—Ventilating railway carriages
1383 H. Highton, M.A.—Making artificial stone, &c.
1384 C. Moore—Screw propeller
1385 C. J. Galloway and H. Beckwith—Slide valves
1386 J. E. Phillips—Sewing machines
1387 R. H. Ray—Reaping machines
1388 T. Welton Applying oxygenated charcoal

### DATED MAY 6th, 1869.

1389 E. N. Hudson—Carriages, &c.
1390 H. E. Newton—Enlarging and reducing basso-relievo
1391 C. D. Abel—Treatment of cast iron
1392 J. Tolson—Cleaning the cards of carding machines
1393 W. Bennett and J. Currall—Improvements in kitchen ranges
1394 I. Battinson, G. Battinson, and T. Whitehead—Combing wool
1395 W. Galloway—Retarding railway trains
1396 W. Galloway—Communicating between passengers and guards
1397 J. Needham—Velocipedes
1398 G. Kent—Refrigerator
1399 J. M. Hart—Safes, &c.
1400 G. T. Bousfield—Braces

### DATED MAY 7th, 1869.

1401 E. Seyd—Fluid meters
1402 R. Fennelly—Washing out casks
1403 D. and A. Posaner—Pipes for smoking tobacco
1404 G. N. Mansfield—Parquet flooring
1405 J. Ramsbottom and T. M. Pearce—Steam apparatus for pumping
1406 A. J. Murray—Reaping machines
1407 F. Leonardt and H. Hewitt—Metallic pens
1408 J. G. Tongue—Envelopes

### DATED MAY 8th, 1869.

1409 F. C. Knowles—Converting cast iron into malleable iron
1410 W. Henderson—Finishing woven fabrics
1411 B. Hunt—Horse collars
1412 H. Myers—Furnaces
1413 E. Maybury, G. Matthews, and E. Marston—Puddling furnaces
1414 R. Cadbury, G. Cadbury, J. M. Rendall—Biscuit from the cacao bean
1415 E. S. Copeman—Communicating between the several parts of a railway train

### DATED MAY 10th, 1869.

1416 A. B. Hawes—Bottles
1417 W. N. Nicholson—Hay making machines
1418 H. R. Lumley—Treatment of molten iron
1419 H. A. Dufrene—Preserving meat
1420 E. Field—Steam fire-engines
1421 C. Lauth—Dyeing and printing
1422 R. Blezard—Dressing millstones
1423 W. Currie—Cushions, &c.
1424 M. S. Wolfgang—Cricket balls
1425 R. F. Hoppe—Musical boxes
1426 W. E. Newton—Hardening common or grey cast iron
1427 W. E. Newton—Gun locks
1428 W. B. Smith—Watches, &c.
1429 J. Withers—Water meters
1430 W. R. Lake—Bronze ordnance
1431 H. Bessemer—Malleable iron, &c.
1432 H. Bessemer—Construction and working of furnaces
1433 H. Bessemer—Conversion of fluid crude iron into fluid homogeneous malleable iron, &c.
1434 H. Bessemer—Treatment of crude or pig iron, &c.
1435 H. Bessemer—Construction and working blast furnaces, &c.

### DATED MAY 11th, 1869.

1436 J. Hall—Firearms
1437 E. Brennan—Polishing threads, &c.
1438 C. Cross, A. Heywood, G. D. Wilson, and T. B. Wilson—Velocipedes
1439 T. Dunn—Velocipedes
1440 W. R. Lake—Detergent compound
1441 C. D. Abel—Galvanic batteries
1442 B. Latham—Ventilators for sewers
1443 B. J. B. Mills—Casting metals
1444 J. A. Marden—Invention having reference to steam, &c.
1445 J. B. Payne—Fittings for roller blinds, &c.
1446 L. Wray—Crushing quartz, &c.
1447 A. Vickers—Connecting and sustaining the rails of railways
1448 A. Henry—Firearms

### DATED MAY 12th, 1869.

1449 C. H. Merritt—Basting
14 0 J. Robey—Sugar refining
1451 E. T. Hughes—Tea urns
1452 P. W. Flower and W. Flower—Impressions upon tin plates, &c.
1453 H. Ing—Fastenings for albums
1454 J. B. Handyside—Wheels
1455 T. Bullivant—Window sashes
1456 H. Robinson—Kilns for burning limestone, chalk, &c
1457 J. L. Greatorex—Urinals
1458 P. W. Flower, H. Nash, and R. Heathfield—Coating sheets of metal
1459 J. H. Johnson—Saw teeth, &c.
1460 G. R. A. Glover—Anchors
1461 A. V. Newton—Expressing juices from organic matters
1462 W. F. De la Rue—Obtaining a water mark on paper

### DATED MAY 13th, 1869.

1463 V. De Stains—Wheels, &c.
1464 E. V. Newton and P. M. Crane—Coating ships, boats, &c.
1465 J. Timmins and J. Gayton—Lever fastening
1466 H. Luke—Window sashes
1467 W. A. Lyttle—Electro telegraphic apparatus
1468 T. G. F. Dolby—Valve for the admission of air to feeding bottles
1469 J. Townsend and P. Forbes—Refining oils and fats
1470 I. Battinson, G. Battinson, and T. Whitehead—Combing wool
1471 J. Fawcett—Measuring oil
1472 C. Ferguson—Washing bottles, &c.
1473 J. Bownes—Steaming tobacco
1474 A. Friedmann—Ornament
1475 W. Cadogan—Couplings for connecting together the ends of driving straps
1476 W. Stephenson—Consumption of smoke in furnaces

### DATED MAY 14th, 1869.

1477 I. Storey, J. H. Storey, H. Lea, and T. Lane—Controlling the discharge of water from stand pipes
1478 J. and J. Kippax—Weaving counterpanes
1479 C. W. Lancaster—Concentrating shot
1480 J. T. Griffin—Knives, &c.
1481 W. Finley—Breaks of railway carriages
1482 H. B. Barlow—Cases for bottles
1483 G. F. Henry, I. A. F. Baug, F. R. C. Monestier, and J. P. A. Figuier—Lubrication of sheeps wool, &c.
1484 M. Wolfsky—Fastening for purses
1485 F. Hedley—Horse shoes
1486 J. H. Johnson—Treatment of beetroot
1487 C. E. Spooner and G. A. Huddart—Construction of railways
1488 G. T. Bousfield—Lifting blocks of stone
1489 C. H. Gardner and J. Bickerton—Lithographic printing machines

### DATED MAY 15th, 1869.

1490 I. M. Milbank—Firearms
1491 V. R. Batchelor—Giving motion to wheels
1492 S. Corbett—Velocipedes
1493 L. A. V. Dubourg—Gas
1494 F. E. Saxby and I. M. McGeorge—Conveying persons upon the common road, &c.
1495 W. Wilkinson and M. Boas—Embossing glass metal, etc.
1496 S. S. Jarvis—Collar and tie
1497 T. Berney—Mounting armour

### DATED MAY 17th, 1869.

1498 F. Kohn—Extracting juice from sugar cane
1499 R. Bodmer, J. J. Bodmer, and L. R. Bodmer—Fire grates
1500 R. Wilson—Spinning cotton
1501 H. De Garis—Chandeliers
1502 H. G. Whitehead—Cutlery
1503 R. Harlow—Hot water boilers
1504 D. Hitchen—Looms for weaving
1505 A. Doen and A. Liddell—Metal cans
1506 C. E. Brooman—Applying breaks
1507 T. Wright and I. Fox—Manufacture of lace
1508 S. W. Clark and W. R. Sykes—Railway lamps
1509 W. E. Newton—Sliver cans
1510 W. R. Lake—Firearms
1611 W. R. Lake—Drying sugar
1512 W. R. Lake—Forming the threads of metal screws

### DATED MAY 18th, 1869.

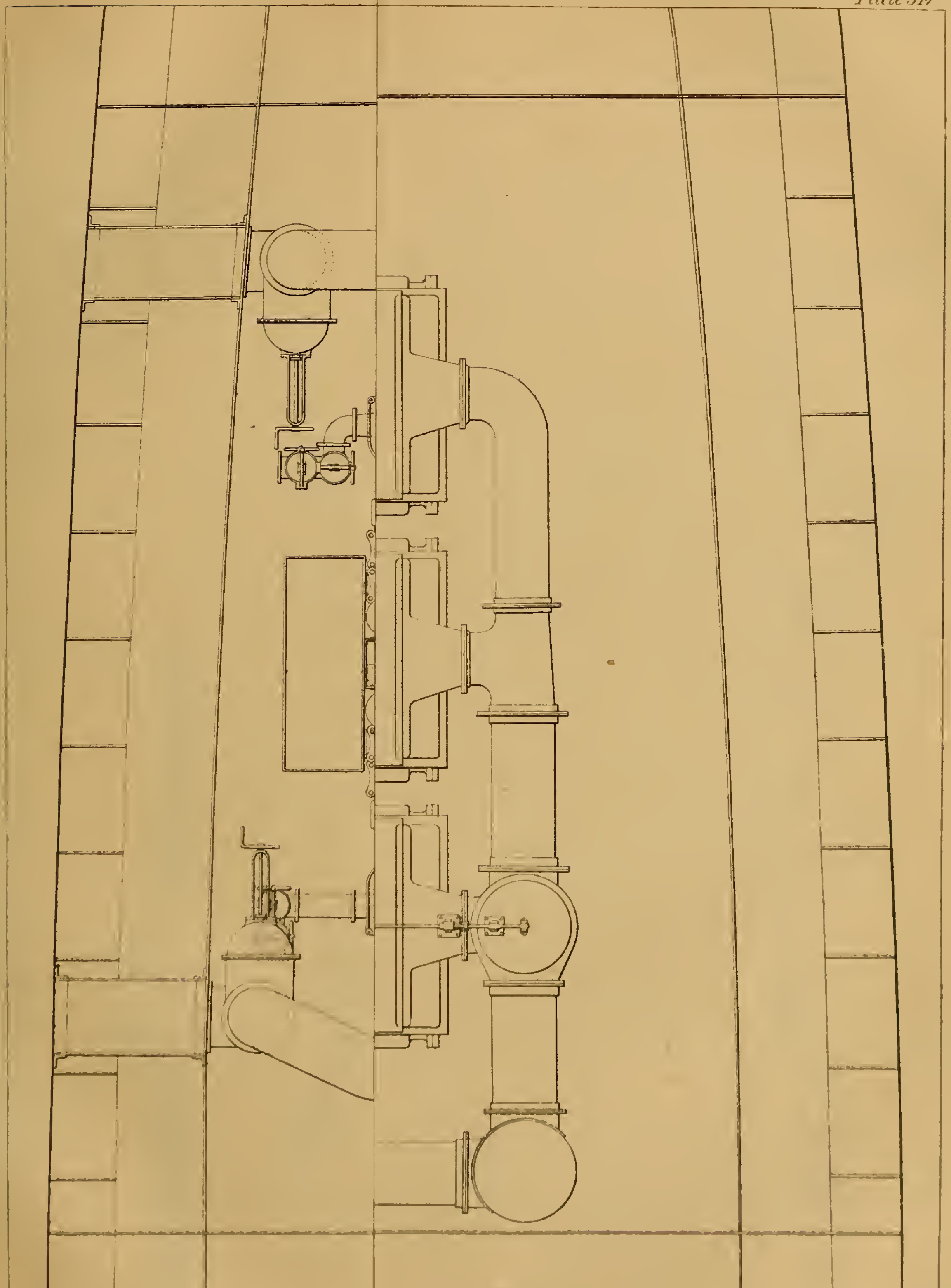
1513 T. Norris—Mowing grass
1514 A. Tatham—Needles
1515 T. Fagg and J. Fagg—Waterproof garments
1516 C. Moseley—Felt hats
1517 J. Norton—Ball cocks
1518 J. Waterworth—Fire grates
1519 A. M. Clark—Locomotive engines
1520 G. Allan—Securing sheet metal employed for roofing
1521 F. Malton—Coal vases
1522 J. Woodward—Gas and water meters
1523 W. Benson—Treating ores
1524 J. L. Clark—Iron and steel tubes
1525 A. V. Newton—Paper hangings
1526 E. C. Warburton—Registering secret votes
1527 F. Johnson and W. Hatchman—Umbrellas
1528 W. Green—Cleaning flower pots
1529 W. Naylor—Railway breaks
1530 J. H. Johnson—Firearms
1531 E. Taylor—Washing, etc.
1532 H. Laveseu and T. Collison—Velocipedes
1533 J. Sawyer and W. Woodman—Propulsion of velocipedes
1534 R. E. Keen—Securing panes of glass
2535 A. Van Winkle—Securing corks
1536 W. R. Lake—Capsules

### DATED MAY 19TH 1869.

1537 E. H. Solly, A. I. Solly, J. F. Hall, and R. Bailey—Spinning two or more ends of yarns into one thread

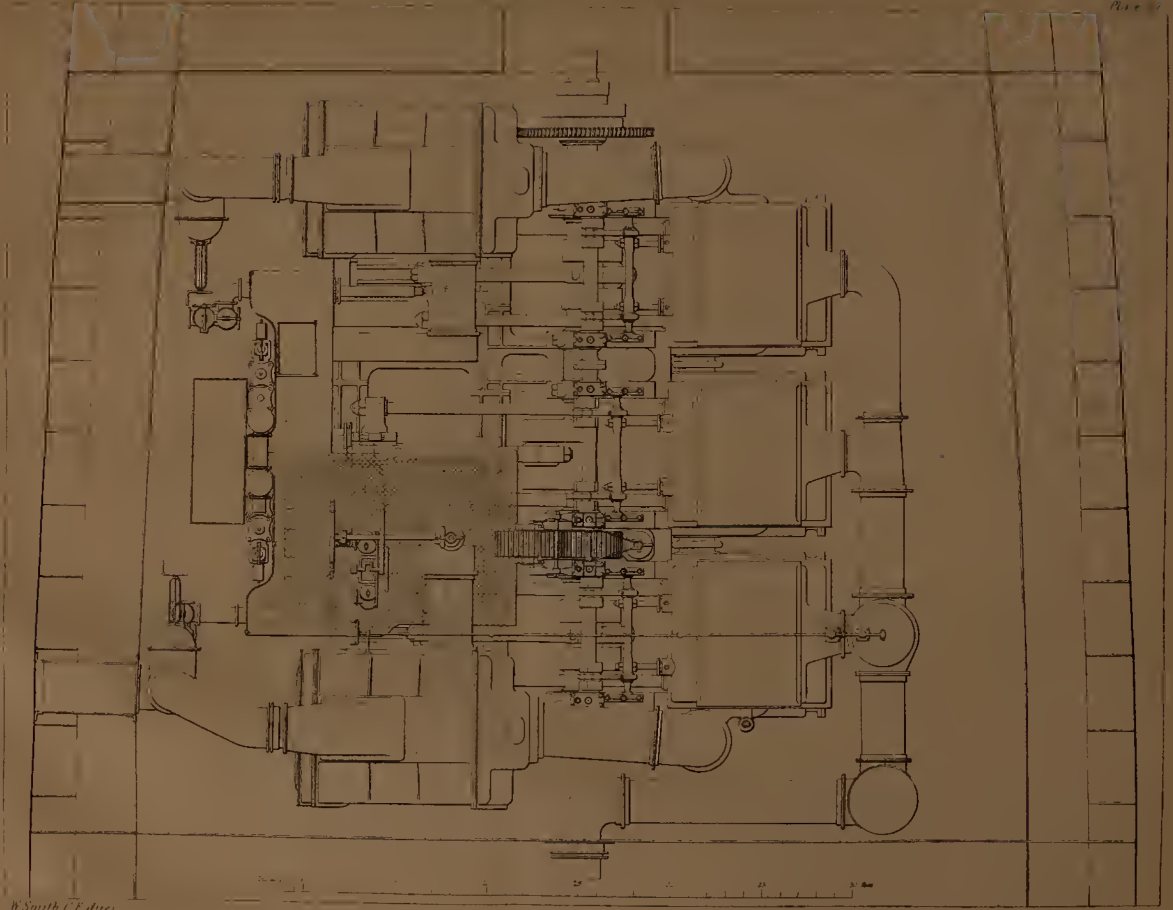
# ENGINEHELM OF 1150 H.P.

Plate 347



W Smith C E direx

[illegible]



W. Smith C.E. delt

FIG 3.

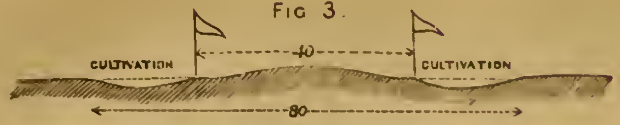


FIG. 4.

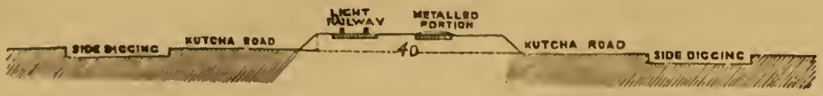


FIG. 2.

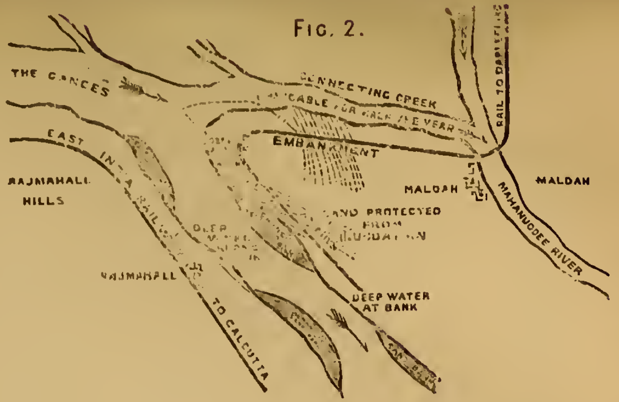
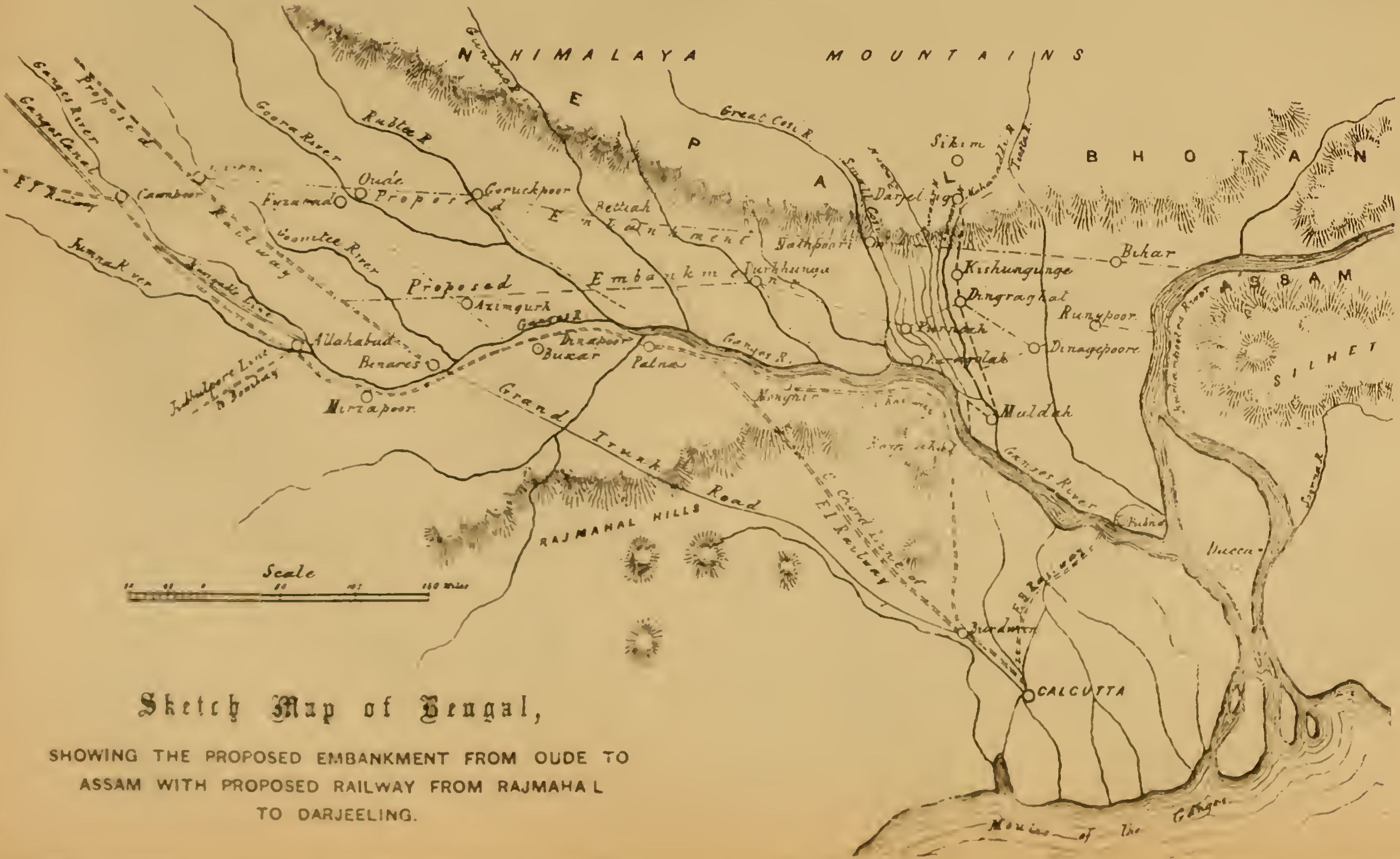


FIG. 5.



# Sketch Map of Bengal,

SHOWING THE PROPOSED EMBANKMENT FROM OUDE TO ASSAM WITH PROPOSED RAILWAY FROM RAJMAHAL TO DARJEELING.

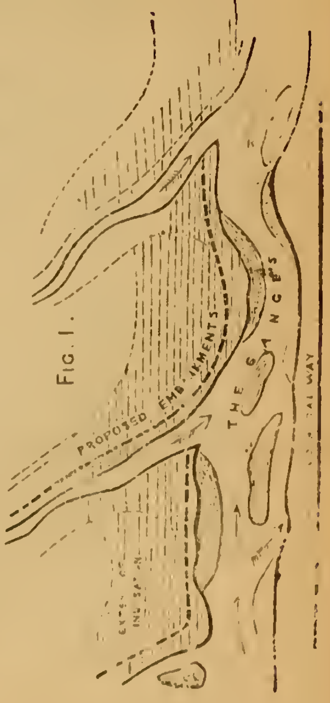


FIG. 1.

R. Smith C.E. delin

# THE ARTIZAN.

No. 7.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. JULY, 1869.

## ENGINES OF THE "KÖNIG WILHELM."

By Messrs. Maudslay, Sons, and Field.

(*Illustrated by Plates* 347 *and* 349).

A notice of the launch of this magnificent iron-clad, from the yard of the Thames Ironworks Company, was inserted in The Artizan for May, 1868; when the principal dimensions of the vessel were given. We now have the pleasure of giving a description, together with a plan and elevation of the engines of that vessel, which were designed and built by Messrs. Maudslay, Sons, and Field. It will be remembered that the engines were calculated to work up to six times their nominal power, and that a speed of from 13 to 14 knots per hour was anticipated, and from the account of her trial trip, given below, it will be seen that both these calculations were not only verified, but considerably exceeded. On the official trial trip, which took place on the 15th of February last, the maximum power exerted by the engines was 8663·889 horse-power being considerably more than seven and a half times their nominal power; while the speed of the vessel was over 14·7 knots, exceeding the calculated speed in about the same ratio. As might be expected, perhaps, of a firm so celebrated as Messrs. Maudslay, for its first-class workmanship, the engines are beautifully got up, and work very perfectly. It will be seen from the Plates (347 and 349), that there are three horizontal cylinders, and that the arrangement is similar to that which was originated, and has been adopted so successfully by this firm for some time past. The substitution of three cylinders instead of two is a more modern improvement, and is for the purpose of obtaining an equability of speed, while carrying a considerably greater amount of expansion than was the custom with two cylinders; the aggregate capacity of the three cylinders being increased in proportion to the increase of expansion. By the use of three cylinders, six efforts, instead of four, are given in each revolution, which not only gives a much more uniform motion to the screw shaft, but almost entirely obviates that unpleasant motion so generally felt in full-powered screw vessels.

The general design of these engines is too well known to need any detailed explanation, but we may mention that the cylinders are jacketted all round and at both ends, and in order still further to prevent any condensation in the cylinders, the casing thus formed is supplied with superheated steam. The superheater is upon Mr. Joshua Field's patent principle; the tubes being flattened throughout the greater part of their length, but left circular at the ends for convenience of fitting. The advantages claimed for this plan are, firstly, that the draught of the furnace is not so much injured, as the spaces between the flattened tubes are greater than if they were left circular; and, secondly, that a thinner current of steam is presented to the heated products of combustion, and consequently the action of such heat is more effectual.

The following are some of the principal dimensions of the engines, &c.:—

Description of engine, horizontal three-cylinder; do. of boiler, tubular; diam. of cylinders, 95in.; length of stroke, 4ft. 6in.; diam. of screw, 23ft.; pitch of do., varying from 21ft. 6in. to 26ft. 6in.; number of blades of do. 4; number of boilers, 8; number of furnaces, 40; breadth of do., 3ft.; length of fire-bars, 7ft. 6in.; number of tubes, 4,400; external diam. of do., 2¼in.; length of do., 6ft. 6in.; heating surface, 22,600 sq. ft.; heating surface of superheater, 2,300 sq. ft.; number of tubes in condensers, 9,272; length of do., 8ft. 6in.; diam. of do. (inside), ¾in.; cooling surface, 17,250 sq. ft.; diam. of chimneys (2), 8ft.; height of do., 58ft.; are of immersed section at load draught, 1,313 sq. ft.; load on safety valve, 30lbs. per sq. in.; gross indicated horse-power, 8,663·889; capacity of bunkers, 900 tons; weight of engines and boilers with water, 1,057 tons.

The following are the particulars of the official trial trip which took place on February 15th, at the Maplin Sands:—

Draught forward, 24ft. 4½in.; do. aft 26ft. 4½in; load on safety valve. 30lbs.; pressure in boiler, 30½lbs.; vacuum in condenser (forward), 27.875; do. aft, 27·875; number of revolutions, maximum 65·333; do., mean, 64; mean pressure in cylinders, 22·483; indicated horse-power (mean), 8,344·917; speed in knots per hour (mean), 14·71; weather barometer, 30·4; direction of wind, W.; state of sea, smooth; masts, yards, &c., complete; description of propeller, 4-bladed; diam. of do., 23ft.; pitch of do., 22ft. 6in.

The greatest power developed was while running the sixth mile, when performance of the engine was as follows:—

$$\frac{7{,}088{\cdot}235 \times 588 \times 22{\cdot}866}{33{,}000} \times 3 = 8{,}663{\cdot}889 \text{ horse-power.}$$

The vessel sailed, shortly after the trial trip, for Prussia.

[We are indebted to Messrs. Maudslay, Sons, and Field, for the dimensions and particulars, and to Mr. Bourne for the use of the drawings and plates.]

## PRACTICAL NOTES ON ROADS AND CANALS.

By T. Login, Esq., C.E., Exec. Engineer, Seventh Division, Grand Trunk Road.*

In selecting a new line of road, the following suggestions may be of service in assisting the engineer in determining what line should be adopted.

The average section of our Imperial roads in Upper India may be taken at as follows:—

Breadth of top of embankment, 40ft.

Height of embankment, 4ft.

Slopes, 5 horizontal to 1 perpendicular.

Breadth of arches of bridges, 30ft.

Breadth of metal, 16ft. by 9in. thick.

Rate of earthwork, Rs. 2-8 per 1,000 cubic feet = 5s.†

Rate of consolidated metal, per inch per mile, Rs. 750 = £75.

Cost of maintenance, per mile yearly, Rs. 750 = £75.

Cost of drain bridges, per running foot of water-way, from 75 to 100 Rs. up to 15ft. span.

Cost of large bridges, from 300 to 400 Rs. per foot.

The rates here given will be found a close approximation to the actual cost, only that for earthwork is rather over than under what the probable expenditure may be.

From the above data we obtain the following comparative cost of embankments, bridges, and metal.

Cost of one mile of embankment (40 + 20) × 4 = 240, @ Rs. 2-8 per 1,000 = 0·60 or Rs. 0-9-7 per foot = £0 1s. 2½d.

$$\therefore \text{One mile costs } 5{,}280 \times 0{\cdot}60 = \text{Rs. } 3{,}168 = £316\ 16\text{s.}$$

$$\text{The cost of drain bridges is } \frac{75 \times 100}{2} = \text{Rs. } 87\text{-}8 \text{ per foot} = £8\ 15\text{s.}$$

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* We have undertaken to re-publish this interesting paper—which originally appeared amongst "Professional papers on Indian Engineering"—with additions and corrections. —*Ed.* Artizan

† To reduce Indian into English currency, change the decimal point on figure, thus, 750 Rs. = £75.

Therefore the cost of one mile of embankment equals only 36ft. of water-way for drain bridges, while only ten running feet of water-way of such bridges as that over the Markunda equal the cost of one mile of embankment.

One mile of metal costs 750 × 9 = Rs. 6,750, or more than double the embankment; and taking the maintenance of road at only Rs. 700 a year for metal, and Rs. 50 for earthwork, at twenty years' purchase, we have for metal 700 × 20 = Rs. 14,000 a mile: therefore the cost of metal is Rs. 20,750 a mile, or more than six times the cost of the embankment.

From the above, therefore, it is evident—First, that all cross drainage should be avoided where practicable, and that the height of embankments should not be so much taken into consideration as the length of road, so as to save metal.

Secondly, as the cost of metal is such an important item, and as this so much depends on the distance from the quarries, in selecting a new line, the proximity to the kunker beds should form a very great reason for adopting one line in preference to another.

Supposing the wear and tear of metal to be 7,500 cubic feet a year per mile, and that eight annas is saved for each mile the road is nearer the quarries, the actual saving would be 7,500, @ Rs. 0-8 = Rs. 37-8 a mile, which at twenty years purchase equals Rs. 750. Thus, if four miles could be saved in carriage, it would equal the first cost of the embankment nearly; or the road may be lengthened one-sixth between two points, without adding to its cost; that is 16·66 per cent. longer, which would admit of a diversion of about one-third of the total distance out of the straight line.

Lastly, where nothing is to be gained by deviating from the straight line, either in avoiding drainage or being nearer kunker beds, the embankment may be raised as follows, without adding to the cost of the road, with the following rates for earthwork:—

Height of embankment up to 5ft., Rs. 2-8 per 1,000.
„ „ above 5 and up to 10, Rs. 3 per 1,000.
„ „ 10 and up to 15, Rs. 3-8 per 1,000.

| | | | | |
|---|---|---|---|---|
| Saving in distance 1 | mile in | 2, or $\frac{1}{2}$, | embankment may be raised to | 13·00ft. |
| 1 | „ | 3, or $\frac{1}{3}$, | „ | 10·00ft. |
| 1 | „ | 4, or $\frac{1}{4}$, | „ | 8·40ft. |
| 1 | „ | 5, or $\frac{1}{5}$, | „ | 7·45ft. |
| 1 | „ | 6, or $\frac{1}{6}$, | „ | 5·00ft. |
| 1 | „ | 7, or $\frac{1}{7}$, | „ | 6·64ft. |
| 1 | „ | 8, or $\frac{1}{8}$, | „ | 6·10ft. |
| 1 | „ | 9, or $\frac{1}{9}$, | „ | 5·80ft. |
| 1 | „ | 10, or $\frac{1}{10}$, | „ | 5·50ft. |
| 1 | „ | 15, or $\frac{1}{15}$, | „ | 5·33ft. |

That is, if the road can be shortened from $\frac{1}{20}$ to $\frac{1}{15}$ of its length, add one foot to height on an average throughout the whole length of embankment; from $\frac{1}{15}$ to $\frac{1}{9}$, add 1½ft.; from $\frac{1}{9}$ to $\frac{1}{7}$, add 2ft.; for $\frac{1}{6}$ and $\frac{1}{5}$, add 3ft.; if $\frac{1}{4}$ is gained, add 4½ft.; where $\frac{1}{3}$, add 6ft.; and where the distance is halved, add no less than 9ft. to the height of embankment. That is, supposing a valley to intervene, which is one mile broad, and requires an embankment averaging 13ft. high to cross it, by going a circuitous road which would avoid this bad ground, and adding one mile to the length of the road (all other circumstances remaining the same along the line, it is as *cheap* to make the 13ft. embankment as to go the more circuitous route, while travellers are saved one mile. In other words, it is very seldom a road should be made to deviate from the straight line on account of earthwork only, except in a hilly country, where steep gradients would interfere.

Considerable deviations can however be made from the straight line without adding much to the actual length of road, as will be seen by the following:—Let A and B (Fig. 1) be (say) 40 miles apart, and half way, at the point C, lay off the perpendicular line CD. Suppose CD is one-tenth of AB, the line ADB will only exceed AB 2 per cent. The engineer, therefore, at half the distance between the two points to be connected, has a breadth of 8 miles to select from, without adding more than 2 per cent. to the whole length of road. If $\frac{1}{6}$, or 16·66 per cent. be added (the limits where the cost of embankment and maintenance of metal equal each other), the divergence may be upwards of 13 miles on either side. Such a deviation from the straight line is much too great; so, in practice, if cross drainage can be saved to the extent of saving only 14 square miles in a distance of 40 miles, it comes to the same thing as to cost, as adding 2 per cent. to the length.

Thus, Rs. 3,168, being the cost of one mile of embankment, we have

$$3168 \times \frac{0{\cdot}8 \text{ (2 per cent. on 40 miles)} \times 7 \text{ (cost of earthwork and metal)}}{87{\cdot}5 \text{ (cost of one foot of water-way)}} = 202{\cdot}7$$

and by page 135 of Vol. II. of Professional Papers, Colonel Dickens allows 42ft. of water-way for 3 square miles;* but by adding 2 per cent. to the length, we do not merely gain 14† square miles, but $\frac{40 \times 4}{2} = 80$ square miles, where the road runs at right angles to the drainage. Therefore, there can be no doubt that where we have a road (say) crossing from the Ganges to the Jumne (all other points being the same), that instead of it being a direct line right across, it should curve considerably upward, as shown in Fig. 2.

The extent of deviation in a distance of 40 miles, and the per centage added to the length of the road is here given:—

| Miles. | | Per centage. | Miles. | | Per centage. |
|---|---|---|---|---|---|
| 1 | in | 40 = 0·15 | 11 | in | 40 = 12·41 |
| 2 | „ | 40 = 0·50 | 12 | „ | 40 = 14·28 |
| 3 | „ | 40 = 1·24 | 13 | „ | 40 = 16·18 |
| 4 | „ | 40 = 2·00 | 14 | „ | 40 = 18·10 |
| 5 | „ | 40 = 3·00 | 15 | „ | 40 = 20·00 |
| 6 | „ | 40 = 4·27 | 16 | „ | 40 = 22·12 |
| 7 | „ | 40 = 5·62 | 17 | „ | 40 = 24·18 |
| 8 | „ | 40 = 7·11 | 18 | „ | 40 = 25·60 |
| 9 | „ | 40 = 8·80 | 19 | „ | 40 = 27·51 |
| 10 | „ | 40 = 11·00 | 20 | „ | 40 = 29·33 |

From which it appears, that so long as the deviation is kept within moderate distances, the additional length is little: for even up to one-fourth of deviation of the total distance, only 11 per cent. is added; but where this is exceeded, the per centage increases fast.

Suppose the bearing between the two points to be connected is 90°, or due east and west, so long as the bearing of no part of the line does not exceed 100° or less than 80°, for all practical purposes the road will be nearly as short as the direct line, while it gives the engineer considerable scope for selecting his line; in doing which, he should consider, first, the drainage; secondly, the supply of metal; and lastly, the earthwork, which, though at first sight it appears the greatest, is in reality insignificant in comparison to the other two items.

A straight line is undoubtedly the shortest distance between two points, but nothing is more monotonous than to have to march along a straight road. In fact, one should never be able to see more than three miles along any road; and this can be easily accomplished by passing round a village or a clump of trees. Curves, however, are unsightly in an open plain, unless there be some natural feature in the country necessitating a curve, such as to cross a stream at right angles, or to avoid low marshy ground, or some high mound. In the latter case the mound can be taken advantage of in hiding the road. Where, however, all is one extensive plain, as one often meets with in India, to put a curve in a road and not to *hide* it, appears as if a mistake had been made in lining it out, which is worse than a continuous long line.

Curves may, however, be given at every three miles, so that no portion of the road can be seen for a greater distance, and the road greatly improved, not only in appearance, but also in comfort to travellers. Suppose the distance between the two points it is necessary to connect is 30 miles apart, and that the country is one open uniform plain, the shortest line would no doubt be quite straight, but it would be too tedious, and would involve long marches of 15 miles each, with nothing to break the monotony of the march. By introducing "Ogee" or S curves at every three miles, and planting too clumps of trees near them on either side of the road, with a well in the centre of one of them, the road could only be seen along three miles of its length, and wearied travellers would have comfortable shade with water to drink. A police Chowkie could be placed in the other clump, so as to afford protection to property.

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* Mr Login in his paper read in August last before the British Association, shows that Nature knows best what water-way a river requires, and that the best guide is to study her

† $\frac{202{\cdot}7 \times 3}{42}$ = 14 square miles.

FIG. 1.

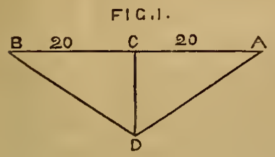


FIG. 2.

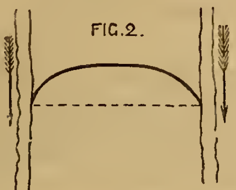
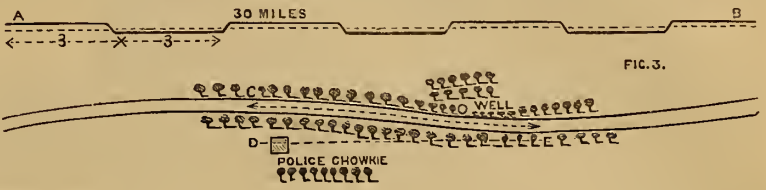


FIG. 3.



Supposing DE (Fig. 3) to be equal to 1,000ft, and CD equal 50ft. then $\sqrt{1{,}000^2 + 50^2} = 1{,}001\cdot24$ft.; or nine of these curves may be introduced, and only add to the length of the road in a distance of 30 miles, some four yards. In practice, therefore, the distances become one and the same, and as to lining out, the engineer need only mark out the straight dotted line and level along it, leaving the classies* to mark out the offsets and lay out the "Ogee" curves with a square and graduated set square, which any intelligent man could be taught how to do in a few hours. This is done by setting off at, say 100ft., at right angles, any distance the engineer considers necessary, and then placing banderoles on the two last pegs, when 100ft. more is measured in the line of the banderoles and another offset fixed, and so on. This plan is to be found described in most engineering works on laying out roads, railways, &c., and calculations are given to find the radius of the circle described with given offsets, &c., &c.; but it is not the intention of this paper to give mathematical details, but simply practical suggestions.

In practice, therefore, it will be found most convenient to lay off the curves, not in circles, but by polygons; that is, supposing the first offset be 1½in., the second would be 3in., the third 6in., next 9in., then 1ft., 15in., and so on. When the centre of the desired curve is reached, the offsets to decrease in a similar manner. By introducing one length of chain in a straight line after the last offset of the curve, the second portion of the "Ogee" can be marked off in a similar manner; thus a set of curves can be laid down on the ground by an intelligent "classie" in less time than it would take to survey and calculate out the proper offsets.

The curves, also, having more the character of paraboles, that is, commencing flat and ending in the same manner, while the centre is sharp, look well on a road, and by many have been considered better for railways and canals. With the railway there is no quick change of the course, which sometimes causes the engine to run off the line. With canals such a curve is better than an arc of a circle, as it causes less sudden derangement of the flow of the water; for it is evident that the tendency of water is to deepen the bed where the velocity is greatest; that is along the extrados; thus there will be a much greater body of water passing down on the one side than the other. Consequently, the water will naturally take to the line of least resistance on leaving the curve, and instead of flowing down in the direct line of a canal, will attack the opposite bank.

In marking out roads through the plains of India, for all practical purposes, if the levels are known at every 400ft., a sufficiently close approximation to accuracy will be arrived at to calculate and estimate the earthwork. At each of these pegs, 400ft. apart, a bamboo should be driven to the required height, and on this bamboo should be marked the height † and number of the peg according to the section. Also much time is saved by cutting on the ground at a little distance from the line the number of each fifth station in large figures.

The barrow pits or tanks from which the earth for the embankment is obtained should also be uniform in size, say 150ft. long, with a space of 50ft. intervening. This enables the engineer to check the measurements at any time, and prevents a flow of water parallel to the road, while it stores up water in the rains that can be used for consolidating the embankments—a matter of great importance in the future maintenance of the road. These tanks should not only be uniform in length, but also of given breadths—advancing by 5ft. at a time—such as 20, 25, 30, 35, and 40ft. broad, according to the quantity of earth required. By this means there is no necessity for measuring the length or breadth, for the eye can at once detect any error; so only the depths are required to be taken, and by having the contents previously calculated out in a tabular form in one's note-book, the contents and cost of each tank is known at a glance.

In practice, after the height of embankments is fixed at every 100ft. along the centre line, an intelligent "classie," with a good eye and an optical square, can mark out the slopes and tanks, and the whole can be done for less than 10 rupees a mile, so that the engineer's time need not be taken up with such details when once he has seen the work properly started.

By this arrangement also the breadth of land required to be taken up is at once settled, and as it consists of long parallel strips, all disputes about areas and boundaries are avoided, while the work of the Civil Officers is much reduced. Much time and money would be saved, and much more satisfaction would be given to the zemindars, if the executive engineer was permitted to walk up the line and pay the villagers on the spot the compensation for whatever trees, crops, &c., there may be on the line, taking receipts for the same. He should always give Rs. 25 per cent. over the market value of what is destroyed. If the loss of time and the pay of Civil Officers' Subordinates be taken into consideration, the cost to Government far exceeds Rs. 25 per cent., while the villagers are better satisfied by getting ready money. If the executive engineer cannot be entrusted with paying such compensation, neither should he be trusted with paying his workmen.

## ROADS, RAILWAYS, AND CANALS IN INDIA.

(*Continued from page* 123).

A navigable canal affords the cheapest means of transporting heavy and bulky goods while at the same time it can be constructed at about one-third the cost of doubling and maintaining the railway line; what therefore appears to the writer to be the best mode to accomplish this is, that the proposed navigable canals be taken up by the railway company, and half railway rates charged on all goods and passenger traffic. Thus, injurious competition would be avoided, while the railway company would secure for itself a cheap conveyance for its fuel as far up as Saharunpore.

This would, for a time at least, avoid the heavy outlay required for doubling the line, while Government could give security to the amount thus saved, in affording a guarantee for some other line, that would add to the military command of the country; and another tract of land would have the benefit of a cheap and rapid mode of transport,

Speaking of roads, railways, and canals, Mr. Login says that he believes that were this carried out, the export of cotton from the north-western provinces would increase more than tenfold; for as the navigable canals would pass through the highly irrigated portions of the Doab, it may be said that the canal boats can be loaded from the very fields and conveyed to Allahabad. At Allahabad, therefore, this cotton would be cleaned and pressed ready to be sent by rail, to be at once shipped off, without the necessity of its being placed in any warehouse in Calcutta or Bombay; thereby much reducing the cost, and thus enable the Indian cultivator to compete with all the world in the production of cotton. In conclusion—By such a system as is herein sketched out, the Imperial Government would be almost completely relieved of the necessity of either supplying funds or supervision for the construction or maintenance of roads, while a desirable emulation would arise among all the district officers of India, as to who could first properly open out their district, which they would be all the more ready to do when they knew that the funds they raised were all to be applied in the improvement of their localities, and not to be spent on works that those who paid the money never heard of, nor the district officers cared for.

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* Native chainmen.

† Allow 1ft. for sinking in every 7ft. of height.

Therefore funds could be raised to make roads, which would be all the more readily provided when the zemindars knew it was for their own personal benefit. The local committee should be allowed to make roads. so long as they adhered to some general system, and had the approval of the commissioner; only when this was withheld, need any reference be made even to the local government.

By such an arrangement as this there would be a great saving to the State, while the attention of the Supreme Government would be confined to guaranteed lines of railway, required for military as well as commercial purposes, while the internal development of India would be expedited the more readily by being entrusted to those who took a personal interest in the improvement of their own neighbourhood.

Thus the Government and the governed, England and India would be benefited when once the relative merits are appreciated of roads, railways, and canals.

As to the mode of constructing navigable canals there is great diversity of opinions.

For the reader to judge properly why this difference exists, it is proper to explain that it is now understood by practical men, that the power required to force a vessel through water increases nearly as the cube of the speed; that is, supposing 1,000 horse-power is required to propel a steamer 10 miles an hour through the water, to increase the speed to 12½ miles or one-fourth more, double the power is required;* nearly thus—

10 by 10 by 10 = 1,000.
and 12·5 by 12·5 by 12·5 = 1,953·

This at once explains why the P. & O. Company do not like to exceed contract rates of speed for conveying the mails, as the consumption of coals increases so enormously.

If we apply the same rule to propelling a boat against a stream of 2½ miles an hour, which is necessary on the Ganges Canal, to give the current sufficient power to transport the silt which is admitted into the canal, we can at once imagine what an enormously greater amount of force must be required than where the rate of the stream is less than one mile. Also that any attempt at great velocities can only be attained at an enormous expenditure of power.

The rate of speed for tracking, which the writer considers about the most economical, will be very near three miles an hour, or rather less, or that speed at which man, horse, or bullock can best exert his power of traction. Any increase on that requires much greater exertion, any less a waste of time. With relays along the canal, a boat can be tracked up stream some 25 miles daily, allowing ample time for cooking, &c. Thus in about 16 days a boat could be brought from Allahabad to Delhi, including stoppages.

Now, supposing the cargo to be 20 maunds of iron, at 5 Rs. a maund, which equals 100 rupees, the loss of interest on capital would be only 16 annas, or one per cent.; while taking the distance at 400 miles, the difference would be—

| | | | | |
|---|---|---|---|---|
| Lowest rate by railway, $\frac{20}{100}$ by 400 at 0-2-1 = | Rs. | 10 | 6 | 8 |
| While by the canal, $\frac{20}{100}$ by 400 at 0-1-0 = | „ | 5 | 0 | 0 |
| Difference | Rs. | 5 | 6 | 8 |
| Deduct for loss of time 15 days…………………… | | 0 | 15 | 0 |
| Gain by canal…… | Rs. | 4 | 7 | 8 |

or there would be a saving of 4½ per cent. in sending up iron by the canal. To attempt to double the velocity on the canal, even if the water was still, the increased force would be in the proportion of as $3^3$ is to $6^3$ or 27 to 216, that is, eight times as great, which would be still further enhanced if the boat had to be propelled up against a stream of 2½ miles instead of at less than one mile an hour.

The rational conclusion, therefore, is, that to attempt to have quick traffic on a canal, except under peculiar circumstances, will not pay. And what are the peculiar circumstances? A high rate of labour and a plentiful supply of fuel, as is the case in America. The very reverse of the state of things we find in India; for this reason alone the speed should be low. There is, however, a still greater reason why steamers with high speed should not be used on the canals in the Doab.

Enough has been said about the light soils of the Doab, and it would not require a long argument to show how unfitted such a soil is to withstand the effects of a wave of translation caused by a steamer passing at great speed up or down the canal. In Canada the canal banks are protected by piles, but in a climate like India, how long would piles, exposed to wet and dry, last? It is the writer's opinion, that if steamers be employed to navigate canals in India the cost of maintenance would be increased tenfold; and all for what purpose? To run in opposition to the railway, against which no canal can compete where time is a matter of primary importance. We may therefore, at least at present, dismiss from our minds all thoughts of steamers rushing up and down the Indian canals, as on the Thames or the Clyde, and content ourselves with coolies and bullocks.

It should, however, be stated, that when boats are passing down country, advantage can be taken of the stream in the main canal for dropping down; so tracking will be required only in one direction, and that against an insignificant stream, just sufficient to prevent rank vegetation and no more.

It was for this reason that Mr. Login eight years ago, suggested navigable canals of slow velocities to be fed by comparatively pure water, that can be obtained from distribution channels, that of the main canal being too silt bearing; and, considering the vast advantage likely to accrue from them to the country, it is desirable that they may set about without delay, when it is to be hoped Sir Arthur Cotton will feel contented that he has been the chief, if not the sole, cause in conferring a great benefit upon Northern India.

In Mr. Login's pamphlet it has been suggested that these navigable canals, as well as railways, should be constructed and worked by private enterprise, and it has also been stated that private companies do not like to undertake such works without guarantees. The question naturally arises—Could not Government, under such circumstances, raise the money by a loan, and make these railways and navigable canals itself?

However advisable it may be to adopt such a system with irrigation canals, the same arguments do not hold good where traffic alone has to be considered. The advantages of the guarantee system are, that Government is relieved of a great many details and references, while the state still holds a sufficient control over these guaranteed lines to serve its interests.*

It has, however, for some years back, appeared to the writer that a modification might be introduced with advantage both to the state and the shareholders. Instead of a guarantee of 5 per cent. being given to the shareholders in all cases, and all profits above this being equally divided between the company and the Government, probably if the guarantee was reduced to 4 per cent. and all the profits were the property of the shareholders, till they exceeded 7 per cent. on original capital, when the division would commence of all profits in excess of this, a great saving may be effected.

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* Note.—Theoretically the power required is as the square, but owing to what is called "skin friction" and other causes, practically it is nearly as the cube.

* Where a line of rail is of great political importance, such as that proposed from Lahore to Peshawur, but where it is not likely to pay in a commercial point of view, possibly this line might with advantage be constructed and worked by Government engineers. This has since been adopted and is being tried.

The writer's reasons for arriving at this conclusion, are:—*First*, that no company is likely to undertake any project that did not hold out prospects of returning more than 4 or even 5 per cent., consequently the best lines for the material improvement of India would be selected.

*Secondly.*—That the prospect of larger returns would naturally make it the interest of the shareholders to see that the works be completed with expedition, and at no extravagant outlay of capital. Thus the necessity of such strict Government control and supervision, with its accompanying delays and expenses, would be avoided.

*Thirdly.*—That the guarantee of 4 per cent. secures the shareholders against complete failure and ruin, in any case; while the interests of the public can be protected by Government having the power of control and supervision, though it may not be necessary to put it so often in practice, as where the company never expect the profits to exceed 5 per cent., and naturally care less about the expenditure.

*Lastly.*—By the introduction of such a system, it appears that while, on the one hand, it protects all parties against projects got up on unsound basis, it at the same time, while holding out an inducement to economy, also admits of a wholesome amount of speculation to give the shareholders an interest in the welfare of their company, which is highly desirable.

With this improvement, the writer believes that now that we are every day having convincing proofs that railways will pay over 5 per cent., it is to be hoped we shall ere long see India covered with a net-work of navigable canals and railways.

(*To be continued*).

## PATENT LAW.

### THE BOVILL LITIGATION.

(*Continued from page* 128.)

I have next to consider what the consequences are which flow from this, both as regards the plaintiff and the defendant. The consequences as regards the defendant are nothing if he has not infringed the plaintiff's patent. Therefore the next thing to be determined is whether the evidence before me is sufficient to prove that the defendant has infringed the plaintiff's patent. The burthen of proving this, lies on the plaintiff. The evidence is to this effect, that the defendant has employed a fan placed on the spindle of the mill-stones, working in the case below the lower mill-stone, and extending a little beyond the periphery of the mill-stone. This fan is driven by the ordinary power of the mill. The effect of the action of this fan is, that the dusty air of the plenum is driven or blown out into an escape pipe, and so on through another pipe or chamber into the open air. Some blast is produced by the centrifugal action of the mill-stones, but the revolution of the fan increases the ordinary centrifugal blast arising from the action of the mill-stones to an extent sufficient to drive the dusty air from the plenum into the escape pipe, without sending out the meal, which descends in the regular manner down the meal spout. I attended carefully to the evidence given on this subject in Court in conjunction with the models then produced, and I listened attentively to the arguments of counsel on this point, and, certainly, no case I have ever heard was better argued. I have since read over again the evidence, and considered the whole matter, and my opinion at the close of the argument—since fortified by my examination and reconsideration of the subject is—that the process used by the defendant, which is Blake and Lee's patent, is substantially—that is in essential points—the same as the plaintiff's patent. The only difference appears to me to be, that the plaintiff exhausts the plenum, or removes the hot dusty air, from the mill-stone case by means of a sucking process applied externally, which draws the air from the plenum through a shaft prepared for the reception of it, and that the defendant exhausts his plenum, or removes the hot dusty air from the mill-stone case, by means of a blowing process, which drives the air from the plenum into a shaft prepared for the reception of it. I do not find that before the plaintiff's invention in 1849, any process had been discovered by which the hot dusty air could be exhausted from the plenum, carrying with it the stive only, and carrying it, not into the body of the mill, but into a separate shaft, where the stive could be collected and utilised. This is done both in the plaintiff's process and in that used by the defendants. The plaintiff sucks the air out, the defendant blows it out; in both instances it is done by a fan. In every case where a fan is driven, it must suck the air from one place and blow the air into another place. In the plaintiff's invention the fan is placed away from the mill-stone case in the air shaft, and it draws the hot dusty air from the mill-stone case into the shaft. In the defendant's invention the fan is placed within the mill-stone case itself, and blows the hot dusty air from thence into the air shaft. It is wholly immaterial, as it appears to me, for this purpose, whether the air that is expelled from the mill-stone case is drawn through the eye of the mill-stone case, or whether it is drawn up through the meal spout, or whether it is introduced through pipes constructed specially for the purpose of admitting the air. The invention consists in producing a blast of sufficient power, and exactly so regulated, as to exhaust the hot dusty air from the mill-stone case, and drive it, with the stive only, into a shaft where it may be utilised, and prevented from injuriously affecting the air in the body of the mill. This appears to me to be done in both cases by the plaintiff and by the defendant, and as soon as the Court arrives at the conclusion that the invention of the plaintiff is not confined to the combination of the methods described in his specification, but that it extends to this withdrawal, whether by expulsion or by exhaustion of the dusty air from the mill-stone case for the purpose of utilising the stive contained in it as a separate and distinct invention, then it seems to me that the defendant has made use of the invention of the plaintiff, and that he has, in all essential particulars, adopted the same process.

With respect to the remaining part of the plaintiff's invention, the separation of the stive from the air drawn or blown into the shaft, I entertain no doubt that the defendant's is, essentially, an adaptation of the plaintiff's process. The blast from the fan must be sufficiently strong to blow the dusty air through the shaft, and, ultimately, into the open air; but, in the defendant's process this is done through a long pipe or horizontal shaft, at the bottom of which is placed the porous fabric which receives the stive from whence it is removed from time to time. I am convinced on the evidence that this, although as I believe imperfectly, performs the same function as the plaintiff's stive chamber performs, that it is intended to be, and that it is an imitation of the plaintiff's process; and that along the whole course of this shaft, air escapes through the porous fabric, and deposits the stive along the course of it, which is removed from time to time by the defendant; and that without the use of this porous fabric the stive would not be utilised.

I am of opinion, therefore, that the process used by the defendant may be correctly thus described, that he has made an arrangement for ventilating the grinding surfaces of the mill-stones by a fan which is attached to the lower stone, and that by means of this fan he exhausts the air from the mill-stone case and removes the dusty air into a shaft, where the air surcharged with stive is partially strained through a porous fabric, and, in doing so, deposits the stive or finer particles of flour, which thereby become useful, instead of being injurious. I am of opinion that the whole of this is an infringement of the plaintiff's patent, and that the invention and mode of doing these things is sufficiently described in the plaintiff's specification, and so construed by the judges of the Court of Queen's Bench has been determined to be valid, in which decision, as far as I am able to judge from the evidence before me, I desire deferentially to express my concurrence. It certainly had not been my intention when I began to hear this case, to go into, or express any opinion upon the validity of the plaintiff's patent, but the course which the case has taken, and the evidence gone into, has compelled me to investigate the matter to the extent of the materials laid before me, and I have thought it proper, that having formed an opinion, I should express it, as it possibly may have the effect of preventing further litigation. I have, therefore, arrived first at the conclusion that the validity of the plaintiff's patent as now claimed by him, has been established at law, and also that the defendant has infringed that patent.

There remains, then, further to be considered, as I have already observed, what are the consequences which flow from these conclusions as regards the plaintiff, and as regards the defendant? In the first place, as regards the plaintiff, I am of opinion that he is entitled to a decree for an injunction; but, on the other hand, as regards the defendant, I am of opinion that I cannot properly compel him to submit to the decision of the Court of Queen's Bench, or to acquiesce in any opinion I may have formed. He was no party to the suit of Bovill *v.* Keyworth; he is not bound by the proceedings in that case; and many cases are on record where, after the plaintiff has established the validity of his patent in one case, it has been decided to be invalid in a second. Numerous cases have been cited before me, which I need not refer to—Bridson *v.* Benecke, Hill *v.* Thompson, Crosskill *v.* Tuxford—which establish that the defendant is not to be concluded by a trial at law to which he is no party, and that he is not to be driven to contest the validity of the patent by a *scire facias*. It is true that the case of Davenport *v.* Goulburn seems to point the other way, and it is also to be borne in mind that the law was established on this point at a time when the Act of Parliament had not passed, which compelled the Court of Equity itself to decide any question of common law which might come before it, without the assistance of any other tribunal, as to which, however, it is proper to observe, that this is not so much a question of law as it is a question of fact. I cannot also but remember, that although I have considered the validity of the patent of the plaintiff, it is only so far as regards the effect of the decision in Bovill *v,* Keyworth, and the sufficiency of the specification, but as to the question of novelty, I have done so solely on the evidence at present laid before me, and I have also done so reluctantly, because I early felt the difficulty I should have, in going into that question, and I checked the entering into it as much as I could, consistently with allowing the defendant to bring forward his case. It is also a matter so far favourable to the defendant that the form in which this case comes before me is that of a cause in which neither side has had an opportunity of knowing before the hearing what evidence he would have to meet, which circumstance tends strongly to prevent the bringing forward of evidence which might, at the hearing, be material, until after the opportunity of doing so is lost. It is after considering all these matters that I have come to the conclusion that the results I have arrived at ought not to prevent the defendant from having, if he is pleased to do so, a further opportunity of trying this question against the plaintiff. I regret it much, because of the great expense which it will necessarily entail on both parties, but I think myself bound by the authorities to direct an issue to try whether the plaintiff is the first and true inventor of the processes described in his specification, or of either and which of them. This issue I will direct if the defendant requires it. I direct no issue as to the utility of the invention, or as to sufficiency of the specification. I consider the former of those matters to be not contested or to be established by the evidence, and as to the second, I consider it to be decided definitively in favour of the plaintiff by the decision in Bovill *v.* Keyworth, which I have minutely examined, and in which I have, after consideration, for the reasons I have stated, expressed my concurrence, so far as it as matter of law, not depending on the novelty of the invention. The novelty of the invention is a question which, in my opinion, I ought to allow the defendant to try again, if he chooses to do so, but, in the meantime, I must restrain him from carrying on his present processes which, in my opinion, infringe the plaintiff's invention. I will reserve the costs of the cause until after the trial of the issue, and give either party liberty to apply.

Mr. Baggallay: As far as regards the form of the injunction, I apprehend we shall take it in the terms of the first paragraph of the prayer, which, I think, is the form in which it has been granted on former occasions.—"To restrain the defendant, his servants, agents, and workmen, for the residue of the term named in the said Letters Patent of the 6th of June, 1863, from in any manner using, exercising, or putting in practice, or continuing to use, exercise, or put in practice at the said Dee Mills at Chester, or elsewhere, the said invention and improvements for which the said Letters Patent of 1849 and 1863 were granted, or any means, apparatus, or arrangement, merely colourably differing therefrom." I desire to have the precise words in order that we may have no discussion afterwards on minutes.

The Attorney-General: With regard to what your lordship has been so good as to say of the defendants, perhaps your lordship would allow us a little time for consideration.—The Master of the Rolls: Certainly.

The Attorney-General: I presume if your lordship directs the issue on the subject of the novelty, there will also be one upon the subject of infringement.—The Master of the Rolls: No, I think I have determined the question of infringement. I am of opinion that it is infringed.

The Attorney-General: Far be it from me to say one single syllable as against anything which your lordship has determined. What was occurr-to my mind was this:—That if an issue were directed on the question of novelty, it might appear upon the trial of the issue that there was no infringement of that which was new, supposing there to be something new, and something not new.—The Master of the Rolls: It is possible that that may be so, Mr. Attorney-General.

The Attorney-General: Your lordship will permit me to put you in possession of the way in which it strikes my mind. Your lordship sees there is a question of combination, and a question of several parts. Your lordship's opinion of what was determined in the Court of Queen's Bench, and for the present, I assume your lordship's own is, that for the present there is a good patent as to the whole, and as to each part.—The Master of the Rolls: Yes, as to number two and the stive chamber. The first is not in question.

The Attorney General: That is all I referred to. That being so, if the question of novelty went to trial, it would be on three points; combination, part two, and part three. Then, of course, it might possibly happen that it might be found that there was novelty in the entire combination, and novelty in part two, but not in part three, and it might be that the infringement fell on that part as to which there was no novelty. I only wish to put your lordship in possession of what strikes my mind..—The Master of the Rolls: I will give you abundant time to consider whether you will take it, and you may also like to take the opinion of another tribunal on the subject. I do not mean that you should determine to take it before you have done that. Of course I will allow the jury to find anything special, as used to be done formerly when we gave liberty to the judge to endorse anything special on the *postea*—that used to be the old fashion in Chancery.

Mr. Hindmarch: In Kay *v.* Marshall that was done.

The Master of the Rolls:—I will allow you to do that; but all the issues I mean to direct are the issues of the novelty of the whole and each part, and reserving to myself the question whether it has been infringed.

The Attorney General: We wish to understand what your lordship's is, and, having done that, we have not a word more to say about it. Your lordship sees the jury would not have before them the question of infringement, but your lordship would; and if the verdict of the jury came back against the novelty on some point.—The Master of the Rolls: The jury would have it before them in this way, because you would be at liberty to do this:—If you can show that any person before Blake and Lee's patent adopted the same process before Mr. Bovill introduced his, that they had a fan by which they expelled the hot dusty air from the mill-stone cases, then it follows from my decision that Mr. Bovill's invention is not new.

The Attorney-General: Yes, it does.—The Master of the Rolls: According to my decision.

The Attorney-General: I do not all wish to offer my objection about that, because after all it will come back to your lordship; and if your lordship found that what had passed at the trial effected your judgment on the point of infringement, we cannot doubt that every attention would be paid to that in a further stage of the cause.

Mr. Baggallay: With reference to what has fallen from my learned friend, the Attorney-General, I think I understand the permission or rather the option, which your lordship offers to the Defendant is this—to try the question of novelty by an issue, and that question will involve the questions of the novelty of parts two and three, and of the combination, but not travelling beyond those.—The Master of the Rolls: That will be so.

The Attorney-General: I quite understand your lordship.

The Master of the Rolls: I am also willing that this should be understood: I am of opinion that this is an infringement, but assuming that the jury were of opinion that it was not an infringement, and, upon that assumption held that Mr. Bovill's process was a new one, because although a process exactly the same as that which the Defendant used was used before, in their opinion they were distinct and different.—The Attorney-General: Yes, that occurred to my mind.

The Master of the Rolls: That I allow you to bring expressly before the jury, and in that form you may try the question of infringement, but in no other. I am not bound, of course, by the decision of the jury, although, of course the decision of the jury would have great weight with me.—The Attorney-General: I understand you to permit us to consider not only whether we will try the simple issues upon the novelty of these three claims of the plaintiff, but if we are able to suggest anything proper to be considered by your lordship we should be at liberty to suggest and additional issue upon the particular process which we are using.

The Master of the Rolls: No, I do not think that, but you may give evidence to show that the particular process was used.—The Attorney-General: Just so, and no objection will be taken by the other side that that was not the issue.

The Master of the Rolls: No, you may say that is so, that it being the opinion of the Master of the Rolls the processes were in substance the same.—The Attorney-General: I quite follow your lordship.

Mr. Baggallay: Would your lordship think it right to postpone the accounts as to the extent of the infringement which has heretofore taken place?

The Master of the Rolls: Yes; the accounts, generally speaking, are not worth much.

Mr. Hindmarch—Does your lordship give the plaintiff the same notices of objections as in the case before a jury at law?—The Master of the Rolls: No; I only send and an issue. If you try the validity of the patent, then they will give all the notices of objections in the usual form.

Mr. Hindmarch: Pardon me, my lord. With regard to want of novelty, the defendant always gives notices of objections, that is, he states what cases of prior user and publications he intends to rely upon.—The Master of the Rolls: In that case you will follow the practice at Common Law.

Mr. Baggallay: Will your lordship direct a time within which the option should be exercised?—The Attorney-General: I was going to ask his lordship for a week.

The Master of the Rolls: That is a very short time; I will give you longer if you wish it.—Mr. Selwyn: No, we wish it done speedily; we do not ask for further time.

The Master of the Rolls. You will have until this day week.

The Attorney-General: It will be put in the paper to be spoken to.—The Master of the Rolls: Yes.

Mr. Baggallay: I apprehend your lordship will try the issue yourself.

The Master of the Rolls: No, I do not think I should. I am particularly desirous not to try the issues, because I think I have a bias on the subject, and I wish it to be tried by a perfectly fresh mind. I think it is the only fair for the defendant. It is impossible to hear what I have said without seeing that my bias is rather against the defendant. I want the thing to be perfectly fairly tried by another judge and by a jury. That is to say, my opinion is against the defendant, supposing he has no fresh evidence. I do not suppose it would affect me if fresh evidence were given.

Mr. Baggallay: That is a question which will have to be decided when it is brought before your lordship again.—The Master of the Rolls: No, I should wish it to be brought in one of the courts of common law.

Mr. Baggallay: That may turn on the question of the terms of the Act of Parliament.—The Master of the Rolls: I may direct an issue.

The Attorney-General: No doubt of it.

Mr. Baggallay: I think there is a difference between an interlocutory application and the hearing of the cause, but inasmuch as we have not now that question before us, perhaps I had better not go into it.

The Master of the Rolls: I think the court has power to direct an issue at all times.

The Attorney-General: I believe your lordship will find in the Act that power, but I am quite sure if your lordship does not, the express intention of those who drew the Act will be disappointed.

The Master of the Rolls: I have not looked at the Act on that point, but of course it is very material, because if that were so, as I do not intend the defendant to be deprived of that right, I should put it in another form.

The Attorney-General: Quite so. I quite follow your lordship, and I believe if your lordship looks at it, it will turn out there is no doubt, whatever, on the point.

The Master of the Rolls: If I have no power to direct an issue in that form, I will alter the judgment entirely, and put it in a form in which the defendant shall try it effectually.

The Attorney-General: If your lordship pleases.

We have seen that in Bovill *v.* Keyworth the Court of Queen's Bench gave judgment for Mr. Bovill, upon the notion that the jury had found the specification to be sufficient, and upon the footing (of which no hint was given at the trial) that the exhaust was to be regulated or proportioned to take away the plenum caused by the blast, and not to produce an inconvenient current. The judgment of Lord Romilly was that the invention consisted in removing the dusty air from plenum, and that this was done by Mr. Goodier, who did not use any exhaust form his mill-stone case, but had a fan in the bottom of the mill-stone case which blew out the stive through a sort of a chimney. It would appear that Lord Romilly was of opinion that the ventilation of the grinding surfaces of the mill-stones was not an object of any importance in Mr. Bovill's specification, and that the sole improvement lay in getting the stive away from the mill-stone case. It is useless to enlarge upon the absence of thought, and consequent confusion of language, which pervade this judicial exercitation. The reluctance exhibited in allowing Mr. Goodier a trial by jury of the question of novelty, and the arbitrariness of confining the jury trial to that one question seem departures from the general course of holding the scales evenly between the parties. But the position of the learned judge is not wholly unintelligible. He was familiar with the old system in Chancery, which was that that court should not itself try the validity of a patent, but confine itself strictly to enforcing by injunction, and by directing accounts, the legal right under the patent, which had been established as a valid against the defendant in that suit, by an action at law against him. The injunction was sometimes granted by the court, even before the action had been tried against a particular infringer, provided the validity of the patent had been successfully maintained against other infringers; and Lord Romilly's enquiry as to what the Court of Queen's Bench had done in Bovill *v.* Keyworth was precisely the investigation which would have been made if the Court of Chancery had been asked to issue a temporary injunction against Mr. Goodier, in anticipation of Mr. Bovill eventually succeeding in an action upon the patent. But times have changed, and even the Court of Chancery has had new duties imposed upon it, although Lord Romilly does not seem to have imbibed the new ideas. His admission that the judgment on Bovill *v.* Keyworth would not be conclusive at law in a fresh case, is an emphatic condemnation of the decision he pronounced; for that decision was nothing else than a conclusion of Mr. Goodier by the judgment in Bovill *v.* Keyworth. The danger of putting new wine into old bottles is shown by this decision. The reforms in the Court of Chancery had made it impossible for Lord Romilly to act upon the old familiar plan of sending the question of the validity and infringement of the patent for trial in an action at law, and imperative that he should himself try those questions with the assistance of a jury if he thought fit to have one. After the interruption of the case, we have recorded, it can hardly be considered that Lord Romilly had any fair opportunity of himself trying these questions, indeed, he said he would not try them, but in the end he decided that some of these questions had been decided by a court of law on a previous occasion between other parties, and he would not permit them to be re-opened except in so far as other evidence of prior use of the invention might be procurable by Mr. Goodier. This is plainly putting a limitation upon a defendants' rights, which may lead, and in this very instance led to serious consequences. It makes the reform in Chancery capable of working out this result—that whereas fomerly a defennant was entitled as matter of right to have a trial by jury and the judgment of a court of law, as to the validity of the patent; the Court of Chancery may in its discretion refuse to let him contest the question, because another person had previously done so unsuccessfully. It would have been well if Parliament in its desire to relieve parties from the expense of trying a case at law as well as in Chancery, had been more careful to secure that the case should be tried at all.

The question of novelty of Mr. Bovill's inventions was tried in December, 1866, before Mr. Justice Willes and a special jury at Westminster, occupying six days.

(*To be continued.*)

## THE ABRADING AND TRANSPORTING POWER OF WATER.

(*Continued from page* 130).

Although this subject was treated upon in last month's Artizan, we feel sure we need make no apology to our readers for extending the remarks upon such an important question, one of such general interest to the engineering profession at large. As the more we consider the questions which are opened by Mr. Login in his original papers, the greater the number of subjects to which we find it is applicable, and upon which its influences operate.

### Its Influence in transporting Sewage.

The transporting power of water, when conveying sewage, is becoming a subject of very great importance, as both the fertility of the soil and sanitory state of our large cities are affected by it. It is now pretty generally admitted, that plants can best absorb nourishment from the soil when the soil receives the manure in a liquid form; but it also would appear that vegetables do not thrive so well when the water is very highly loaded with sewage.

There would, therefore, seem to be some certain proportion of water and sewage best adapted for the soil to absorb and again to give it off to plants; and possibly this very proportion is also the best when water is the medium by which the sewage is transported, while at the same time it may be found that a city requires just this quantity of water to insure proper sanitory measures being carried out.

It is self-evident that the refuse of our cities could not be made to flow without water—be the slope or the head of pressure ever so great; and also that pure water will flow with almost an imperceptible slope, but under such circumstances this pure water could not hold in suspension any foreign matter. Again, as it is necessary that sewage should be conveyed under ground for sanitory reasons, and that to utilise this sewage for irrigation it will require, under most circumstances, to be again pumped up, the question is, what is the velocity, in other words, the slope or head of pressure that should be given, which will require the least power to be expended in pumping?

If too little water be used, we must increase the fall, while too much of it involves needless pumping. It is, therefore, quite possible that it may be discovered that the proper liquification of sewage, so as to have the least expenditure in pumping, may be also the very same proportion per head required by our cities for sanitory purposes, as well as the very best proportion for agriculture.

The question, though very complicated, is one of great interest; and its importance is becoming more and more evident. That the soil can, when irrigated by sewage water, absorb the foreign matter, and give it out again in the best possible state for the growth of plants, is admitted, while the water being relieved of this matter, sinks into the ground below in almost a pure state; so this very water, which has been taken from a river high up its course, can be made to supply our cities: then convey away the refuse, distribute it over the fields, adding to their fertility, and again return to the parent stream through the under-ground springs in a state to aid rather than injure navigation, for it brings no foreign matter along with it.

### Its Influence on Sewage under Pressure.

According to Beardmore a bottom velocity of 40ft. a minute will sweep along course sand and 60ft. fine gravel, but this is with pure water not already loaded with solid matter. What may be the necessary velocities with various loads of solid matter held in suspension, are questions yet to be determined by experiment. So as water holding sewage matter in suspension must be affected by the load it has to carry, the velocity requisite for sweeping along coarse sand under such circumstances, must be much greater than if only pure water was the disturbing medium.

For the sake of argument, suppose that a mean velocity of 1ft. a second is the necessary velocity in a closed pipe, the question is, what is the size of pipe required to convey away the sewage of a given number of inhabitants?

Let this number be 100, and that two cubic feet of water (rather over 12 gallons) is the water supply for each man, woman, and child, during the 24 hours.

Now, as eight out of the 24 hours is required for sleep, there remains only 16 hours of the day that the greater portion of the sewage is supplied, and during certain hours of the day there must be a greater discharge than at others; allow one-fourth more to be deducted to admit of the maximum discharge, or in all only 12 hours.

The rate of discharge per second would therefore be

$$\frac{100 \times 2}{12 \times 60 \times 60} = 0.048 \text{ cubic feet,}$$

or 82.944 cubic inches, which it is supposed requires a mean velocity of a foot a second, that is 12 inches; so $\frac{82.944}{12} = 6.912$ sqr. inches. is the sectional area required for a pipe to discharge the sewage for 100 inhabitants; or a three-inch pipe is sufficient to pass off this maximum discharge of sewage of 100 men, women, and children.

Again, suppose that the ground is such that there is *no available fall* along the line this sewage has to be discharged, and the length of pipe is 500 yards, the question is how to obtain the velocity of one foot a second?

Adhering to Beardmore's tables, the discharge being 0·048ft. a second, or 2.880ft. a minute, distance 1,500ft. and diameter of pipe 3in., there is

$$\frac{1{,}500}{\left(\frac{73.6}{3}\right)^2} = 2\tfrac{1}{2}$$

That is, with 2½ft. head of water and a three-inch pipe (which is 500 yards long), in 12 hours this pipe could discharge the sewage of 100 inhabitants, but if the head of water was raised to 10ft., this same pipe could discharge more than four times as much.

The question is, how is this fall to be obtained on perfectly level ground? and the answer is by pumping; but it is obvious that *all* the water does not require to be pumped, but only a small portion of it, by simply having all the water-closets in a house above the level of 10ft.; and whatever water may be used in the kitchen or ground floor only, can be pumped up to the required level, a work that would hardly occupy the kitchen servants above quarter of an hour daily. There will also be this advantage, that, having to pump up all the dirty water in the sink or cesspool, no bulky matter could find its way *up* the pump, but would have to be removed by hand to the ash pit, to be carted away in a dry state; thus there could be no danger of the sewage pipes being ever blocked up by solid matter.

Mr. Chadwick, in his report on the Paris Exhibition on dwellings for the working classes, has drawn attention to a number of most important sanitary questions, of which the above is one of them, and at page 76 of this able report points out, that fresh sewage that has not undergone the process of decomposition is not only more valuable in its fructifying power in the proportion of one to three; but, instead of killing fish when it escapes fresh into a river, the fish come and feed on it. So the qestion is, why is it that there has been so great an outcry about the evil effects of the sewage of our cities?

The reply is, that it is from a want of a proper knowledge of the abrading and transporting power of water, and to prove this one example will be sufficient. At a well known watering-place on the west coast of England, the Local Board of Health are at present constructing a culvert to convey away the drainage and sewage of a portion of the town. The land is nearly level, so there is no great outfall that the sewage and drainage can flow off quickly by its own gravity. To provide, therefore, for this want of natural fall, the channel along which the sewage and drainage is to escape is made large, the culverts being 2ft. by 1½ft. of egg-shaped section. The houses for which this sewer is being built are twelve in number, containing something rather under 100 inhabitants, and this drain is 500 yards in length, which will cost somewhere about one pound sterling per running yard, which, at 5 per cent., is an annual tax of rather over £2 a house.

Now the first mistake made in this town, we are of opinion, is combining the storm with the sewage drainage: for the former could, with impunity, be permitted to drain into the sea, but this mistake probably arises from a want of a proper knowledge of the abrading and transporting power of water, for if the storm drainage has already got its proper load of solid matter, where probably the slopes over the surface are much greater than within the culverts, it is evident that the highly charged storm water cannot aid in scouring out any prior deposit, but will rather add to it. Consequently the admission of this storm drainage rather tends to block up the culvert sewers instead of keeping them clear, so there can be nothing gained by having large sewers to convey away the storm drainage also.

It has been said that the sewer now being built has a section of 2ft. by 1½ft., but taking the nearest size to this, 2ft. by 1¼ft., given in Beardmore's tables, where there is a fall of 2ft. in the mile, with a depth of 12in. of water in the culvert, we only get a velocity of 59·9ft. a minute, or what we started with, as required to move along sand by sewage water; but we also find that to give this depth of water, the discharge requires to be no less than 52ft. a minute., or eighteen times more than the sewage of one hundred inhabitants, while with any decreased velocity it is supposed sand cannot be transported. The natural consequence is, therefore, that the sewer must get filled up, till it has reduced the opening to such an area that the velocity acquired by having to pass through such a small opening can enable the water to sweep along sand, or, in other words, the culvert sewer gets filled up with decomposed putrid sewage, that poisons the air, earth, and water, while for some one-tenth of the cost probably, a proper system of sewage pipes could be laid down, so that even a new set of pipes could be laid down every other year at no greater cost than the interest on capital laid out on the culvert sewer.

By this head of pressure system also, it is evident that for irrigation purposes there would be little trouble in spreading the sewage over the lands, while by the increased velocity the land would receive it in a fresh state, and thus the greatest benefits to the soil would be secured without any deteriorating effect on the health of the inhabitants, and all at what cost? Merely that the kitchen servants, for a quarter of an hour or so daily, would have to pump up the water in the cesspool to a higher level of some ten feet or so above the sewage-pipe outfall, and thus all these ingenious methods of separating all sorts of rubbish would not be necessary; for they could not be pumped up from the sink, so that only paper in a state of pulp could pass down the pipes. The servant girls might at first object, but not where sewage arrangements are introduced for the first time, and once the advantage of this system were proved, all objections would soon disappear.

### Its Action at Weirs and Spurs.

A knowledge of the abrading and transporting power of water is of great importance in the construction of weirs and spurs. The object of the former being to hold up the surface level of the water when a river is *not* in flood, and to admit of a free flow of the water when a flood is passing down.

With spurs or groins, on the other hand, the object is quite different; and it is to *retard* the flow of a silt-bearing current at points where abrasion is taking place, so as to cause deposit, rather than a cutting action at the points required. Regarding weirs, it may be said that they can have no injurious effect on the bed of a river, so long as the sectional area of the stream over the lip of the weir, during a flood, is greater than the smallest sectional area of the stream below the weir.

During a flood, it is evident that having a weir across the bed of a stream that admits of a free flow of the whole volume of water, cannot have any effect whatever in raising the bed "up stream," for it cannot *retard* the velocity. And down stream, except in the immediate vicinity of the works, owing to the disturbance caused by the change of the general direction of the flow of the stream, which requires to be guarded against by protective works, a weir can have no bad effect, for the water will flow down as it did before the weir was built, with the very same volume, velocity, and load of silt.

It has been supposed that by throwing an artificial bar, or weir, or any obstruction across the bed of a stream, such as the flooring of a bridge, it will hold up the bed of a stream; *but such is not the case, unless the surface of the water be held up also.* To do this—that is, to contract the water-way—increases the velocity, which at once endangers the stability of the work; for where there is any increase of velocity, then there must be scour to such a depth that the stream, owing to the increased depth, can only transport water holding in suspension solid matter, in the same proportion as the stream did in its normal state. What is found to occur, therefore, is a deep hole scoured out at the point of contraction, and a few yards below this the very same matter is again deposited, as soon as the river again attains its natural velocity, and at once the hole is scooped out to the necessary depth to admit of the water with this increased velocity, and its natural load of silt being carried forward, all further cutting then ceases; for the abrading and transporting power is directly as the velocity, and inversely as the depth, in some proportion which can only be determined as before suggested by a series of carefully conducted experiments.

In cases, however, of mountain torrents of great declivity, and whose beds may be said to be all moving down to a depth of several feet below what is the bed of the river, when not in flood, these holes may not be so apparent after a flood has subsided, for they get filled up as the flood decrease by the shifting sands filling up the deep hole. Yet nevertheless they do exist during floods; and this is proved, by the whole work sometimes disappearing in these holes, and being again covered over.

With spurs or groins, it has been already said that they are intended to *retard* the velocity; but it sometimes, nay often, happens that they become nothing more or less than submerged weirs, and, instead of decreasing the velocity, actually increase it at the very point where it was hoped there would be a deposit.

Instead of only admitting a limited volume of water *through* them, and forcing the remainder to pass *round* them—thus retarding the flow of the silt-bearing water on both the up and down stream sides of the groins, and causing a deposit—these spurs often, instead of retarding the flow in their vicinity, and ultimately diverting the general stream, cause the water to flow *over* them at an increased velocity; and instead of doing good by causing deposit, do, in fact, by giving a plunging direction to the water, produce a scour in the same manner as building a pier in the bed of a river; and it sometimes happens that the deepest water is found round the obstruction. It is thus, by a want of the proper knowledge of the abrading and transporting power of water, that large sums of money are often expended on works connected with water in motion,—and the result is most unsatisfactory, by reason of injury instead of good resulting therefrom.

### Its Effect on the Water-way of Bridges.

Should it be correct that the abrading power of water becomes *nil* when once the stream has its proper load, and the transporting power is directly as the velocity, and inversely as the depth, it is evident that to determine the proper water-way for bridges becomes very much simplified; for in all rivers passing through alluvial plains, nature will have given to the stream the requisite load due to the velocity and the depth, any change being simply of a local nature. This at once saves the necessity for long and extended surveys of catchment basins, registers of rain-fall, and measurements of discharge or velocities; for the channel itself becomes the best of all tests, for it shows what volume of water must pass down, and that the soil can and has stood the wear and tear.

To attempt to determine the water-way by detailed surveys of the catchment basins, leaves a vast field for speculation; for not only must the exact area be known, but the greatest rain-fall in a given time, as well as its duration, and also the distance the water must travel before it can reach the part of the river to be bridged. Even then, after having got all this accurately, so as to be able to determine the actual discharge, provided it be also known what is the actual absorption; and after having attained all this, having to fix some rule as to velocity by determining that it should not exceed, say three feet a second, when in nature it can pass off harmlessly with velocities exceeding half-a-dozen feet,—the water-way must be much too great if the velocity determined on be too small, and too contracted if it be fixed at too high a speed, and so will prove such a rule to be empirical.

Thus, it sometimes happens that a bridge may be safer by *reducing* the water-way, for it only gives the stream more room to meander about, and so enables it to approach the bridge in an oblique direction, and thus cause a violent scooping out at some corner to a greater depth than if the water-way was contracted, and the river forced to approach the works at right angles to the line of the bridge.

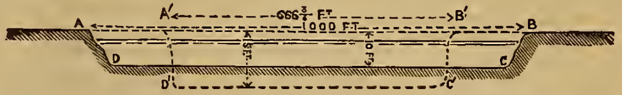
From the foregoing it will be seen, that the best, nay, the only reliable data to be guided by is the cross section of the river itself, at some point below the site of the proposed bridge, where the channel is pretty straight. By allowing this sectional area, it is evident that the only derangement to the flow must be owing to the obstruction offered by the piers, for which, allowance has in most cases to be made. That is, supposing the mean hydraulic depth of a stream to be 10ft., and, by having piers built, if this hydraulic depth is reduced to 7½ft., the breadth of water-way would have to be increased one-third more than it was in nature, provided no additional water-way be given by *lowering* the bed at the point bridged.

The latter plan, however, appears preferable; and now that foundations can be sunk to almost any depth, the water-way—that is, the distance between the abutments of the bridge—may be considerably less than the distance between the river banks at its narrowest part. As water does not travel in straight lines, it signifies little what may be the shape of the cross section so long as it has the power to assume its natural section again on leaving the work. Thus, as before shown in the case of a weir, it may be spread out to a great breadth; so, in that of a bridge, this breadth may be reduced while the *depth* is increased.

The effect of increasing the depth will be to cause a slight increase to the velocity; but, on the other hand, the transporting power of deep streams is believed to be much less than shallow ones with equal velocities; therefore, by doubling the depth, this transporting power becomes greatly decreased, consequently there exists some limit where all further scooping-out of the bed ceases, and, if the foundations be carried below the greatest depth at which the bed can be disturbed, there can be no danger. The whole question, therefore, resolves itself into one of expense, or deep foundations against extended superstructure.

Now, as in large rivers, such as those which drain the plains of Upper India, the depth is only a small fraction of the breadth, say $\frac{1}{100}$, if the depth be doubled, the length of the superstructure, within certain limits of safety, may be reduced nearly one-half by sinking the foundations an extra 15 or 20ft.

As, therefore, the difficulty of under-sinking foundations has been overcome by the sand-pump, there can be little doubt but enormous savings can be effected in bridging such rivers; while, by having a deep channel, there is less danger of the river changing its course. That is, taking a stream 1,000ft. broad and 10ft. deep, and another section of the same stream 666⅔ft. broad and 15ft. deep, the narrower and deeper section can pass off the greater volume of water without disturbing the bed.



The reason is, that with the same load of silt the stream can flow down with greater velocity, owing to the greater depth. Thus as A′B′ is one-third less than AB, the superstructure will be proportionally reduced. Thus the narrow section could be spanned by seven girders of 95¼ft. span, while the broad one would require ten of 100ft., or three more piers, which alone would cost more than undersinking the foundations a few additional feet, and thus fully one-third can be saved in the cost of the work.

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## PATENT MONOPOLY AS AFFECTING THE ENCOURAGEMENT, IMPROVEMENT, AND PROGRESS OF SCIENCE, ARTS, AND MANUFACTURES.

By Henry Dircks, C.E., F.R.S.E., &c.

The discussion in Parliament on the 28th May, on the question raised by Mr. Macfie, the member for Leith, in reference to the Patent Laws; and the subsequent treatment of the same by the daily and weekly press, display a singular want of acquaintance with the matter each undertakes to expound, exemplify, and set on a right basis.

Mr. Macfie's interest in the subject which he has thus prominently brought forward, arises from the fact of his having, as a sugar refiner, patented in 1850, certain improvements in refining and preparing sugar, and manufacturing and treating animal charcoal. If he would favour the world with the history of his own case of suffering, in preference to rambling over a mass of incongruous evidence, we might possibly learn the facts from which he deduces the astounding statement that, the interference of the legislature is demanded " to protect commercial interests from the evil consequences of the law of patent right." These being his own words, he can surely inform us what has been his own commercial experience of " the evil consequences of patent right." He alludes to one " evil " arising from the circumstance that " one particular law plea had cost the parties £100,000." Has he also had experience in any " law plea," arising from infringement, or any other cause whatever?

However, in the absence of his personal experience, let us see what he advances on public grounds, to protect " the interests of the nation at large." He starts with the remarkable assertion that, the present patent right in no respect differed " from that our forefathers 250 years ago (1619) thought tolerable." Is it possible that Mr. Macfie can really be so ignorant of historical information on this important subject, as *not* to know that patents of the period to which he alludes were actually of the kind he calls a " property in ideas," and totally different to patents dating from 3rd October 1771, when specifications began to be introduced? Probably he may not be aware of this important distinction, one which has been made still more explicit by the amended law of 1852, requiring the immediate deposit of a provisional specification. But, nevertheless, he insists that, all patents are merely " ideas." We can understand that the Title " improvements in sugar manufacture," is in itself simply an " idea," but surely the Specification which follows, is something more than a vague unexplained *idea*, inasmuch as it makes public all that is requisite to obtain the desired results.

Mr. Macfie's logical conclusions are exceedingly novel. He professed to have " witnesses to prove that Patent Law interfered very seriously with trade "; and he " held in his hand a paper which showed how many wrongs were inflicted by the present system on manufacturers, patentees, and vendors who were not patentees "; and he believed that the Royal Commission of 1862, had found there was " the existence of practical inconvenience from the multiplication of patents." By this means " Ireland, too, was a great sufferer " because " in 1800 there were only two patents," whereas " now they are 2292."

But " the nation at large " has known what it was to be *without* patents, for, as Mr. Macfie himself observes, " in 1650 (during the Commonwealth) the number of patents was naught "; and as above stated, Ireland in 1800, had only two patents. If Mr. Macfie's evidence and arguments are worth any thing, those were glorious times for arts, manufactures, trades and commerce in this country!

I contend that the whole question in dispute affecting the abolition of the Patent Laws, concerns only manufacturers, and *not* "the nation at large," the public, the million. The people never will move in it, simply because they are the gainers, even although some few manufacturers with old works, conducted on old systems, may happen to suffer ever so much during some great reform; such as, for example, the substituting steam engines for atmospheric engines, doing away with spinning jennies, introducing steam propulsion on land and water, or whatever interferes with supposed vested rights. And after all, when thus limited to manufacturers, how few are ever affected to their serious injury, and how many owe their elevation to their enterprise in the early encouragement they have given to some patented novelty?.

Those who argue against Patent Law never keep to one argument, never prove anything. They assert abundantly that trade is hampered, that it is a national calamity, and that the progress of manufactures is impeded. These are their public grounds of groundless complaint. Then they shift to the poor inventor, he has only an idea, he can have "no property in ideas," his law expenses are enormous, patents ruin him, the true inventor gets no benefit, and so forth to prove that the patenting of inventions is a delusion and a snare! Then come their comparisons. Mr. Macfie stated, that "an invention differed altogether from the literary work of an author, which he would continue to protect." So that logically stated a book not being an *idea*, a man may legally claim a property in his book! Such is the miserable reasoning of the opponents of equal protective right in works of genius and talent.

At the meeting of the British Association, held in Norwich, I read the following paper, on the 26th August, 1868, and it appears to me to be particularly pertinent to the present occasion:

Very early records exist among our state papers and scientific literature, affording abundant and satisfactory evidence that men of genius and enterprise engaged in industrial arts and manufactures, have for centuries obtained protection for their individual inventions or improvements of a mechanical or other nature, through the medium of secrecy in their operations, or through the medium of patent monopoly. We have thus the secret process of manufacture, which may confine the use of an important invention or improvement to the sole use of an individual, and which may be for ever lost to society on his decease, as indeed has happened. And we have on the other hand the public process and public use, which an inventor confidently leaves to posterity in consideration of limited patent protection.

Now, what we have specially to bear in mind in reference to these differently situated classes of inventors is the fact that the secret invention is as much or more of a monopoly than any patented invention, with this single difference, that the one must inevitably revert to the public, while the other, whatever may be its value, is in a position to die with the inventor. And indeed there can be no doubt that the advancement of many branches of manufactures has been materially retarded by the discouragement generally given to secret inventions.

Although, therefore, a patent is absolutely a monopoly, it is one differing in no important respect from an individual's right to the full, free, and unmolested possession of his money or merchandise. He who can make two blades of grass grow where only one grew before has an inalienable right to produce double crops on his land without communicating his intelligence to any second person, whereby to enable others not only to compete with himself, but thereby also enlist the co-operation of the entire farming interest in adopting his discovery. Such an one may, therefore, be taken as representing those inventors who work in secret and reap the fullest possible benefit that can arise from their ingenuity and industry, although exercised on limited operations at a large profit.

Now patent law is based on the principle of considering it to be of public advantage to protect the secret invention, whatever it may be, by securing to the inventor the sole use of his invention for fourteen years, under letters patent granted by the Crown. It is thus that patents are now, as of old, obtained on the payment of certain fees, and the lodging of a complete specification (together with drawings, if needful) exactly describing the nature, object, and mode of working the alleged invention or improvement. But the patent laws have, during different reigns, undergone great modifications. The system that obtained during the reign of Elizabeth was strikingly absurd and obnoxious, operating to encourage perverted and fraudulent ingenuity, and it was only on the accession of James I. to the throne that patent monopoly was limited to the "sole working or making of any matter of new manufactures." Unfortunately, it was not at the same time required from the inventor to state more than the title of his invention, to which he generally added an inflated statement of its wonderful properties. This lax mode of obtaining patents for inventions which might be real or purely visionary, continued for nearly three centuries, and it was only late in the eighteenth century that specifications formed necessary adjuncts to the titles of patents.

In considering the subject of patent monopoly we must never lose sight of these progressive stages, otherwise we shall continually fall into the error of raising objections to patent monopoly on obsolete and admitted defective patent laws. From October, 1852, the mode of obtaining patents has been simplified and great facilities afforded to inventors; the patent fees have been considerably reduced and made payable at three stages of the term of fourteen years, amounting to a saving of the inventor of 50 per cent. on the fees for the United Kingdom, as compared with former practice. It is now sought to introduce many excellent reforms to admit acknowledged facilities, and to render patents less liable than they are at present to clash with private interests in similar property, to be effected through the medium of specifications undergoing a thorough examination by an authorised legal and scientific body of examiners.

This sketch, although necessarily brief, brings under observation—1st, Secrecy in invention as one mode of securing to an inventor the monopoly he desires to possess in the products of his own ingenuity; 2nd, The adoption of patent monopoly, under the existing law; and 3rd, The progressive improvements in patent laws from the reign of Elizabeth to 1852.

Letters patent simply afford a monopoly in products which are novel, useful, and economical, the result of individual investigation, ingenuity, and enterprise; and of which the public, that is, the community at large, would otherwise have been deprived. Patent fees are the smallest part of the charges incurred by inventors; hundreds, and oftener thousands of pounds are totally sunk in mere experiments, and often when a valuable patent is obtained its possessor may have to spend years and a fortune in bringing the manufacture to perfection. Metallurgy abounds with examples of this kind, as does also chemistry, weaving, dyeing, ship building and propelling, railways and locomotives, and in short, almost every department of industry. Who, among these arduous workers would have dared thus to devote their time, energies, and capital to reap the cold and doubtful acknowledgements in a pecuniary form from any body of manufacturers, however numerous and wealthy? It is not in human nature to devote capital and ingenuity to the perfecting of mechanical or other operations in arts and manufactures without reaping a substantial benefit, arising from per centage of profit on the advantages gained by introducing a new or improving an old manufacturing process.

Much has been said against patent monopoly on the ground of a large number of patents being obtained for subjects which are pronounced to be frivolous, and of course worthless. Now, a steel pen would possibly come under this category, and perhaps also a button, hook-and-eye, pins, needles, tape, ribbons, gloves, shoes, hats, nails, screws, with others of a similar class. But most of these, like the sewing machines, require ingenious mechanism for their production; and being articles of large consumption, not only is an extensive manufactory erected—one for pens, another for nails, a third for screws, and so on; but the working of the newly-patented article may involve an outlay of capital which surely deserves as much protection as capital employed on patented engines, steam-hammers, and other large mechanical appliances. To some minds all is meretricious, which they cannot immediately understand; and if a dozen instances out of 3,000 patents granted in one year can be shown to be absolutely worthless, the whole fabric of patent law is decried on no better grounds than the production of a few exceptional cases, than which nothing can be more illogical and unjust. The most cursory view of the progress of patent monopoly shows how gradually it increased. Thus we see by table No. 1.

No. 1. THE PROGRESS OF PATENTS, UNDER THE OLD PATENT LAWS ENDING OCTOBER, 1852.

| | | Years. | Patents. | Patents per annum. |
|---|---|---|---|---|
| James 1st…… | 1617—1625 | 8 | 32 | 4 |
| Charles 1st …… | 1625—1642 | 17 | 95 | nearly 6 |
| Commonwealth …… | | | | |
| Charles 2nd …… | 1606—1635 | 25 | 121 | nearly 5 |
| James 2nd …… | 1685—1689 | 4 | 14 | 5 |
| William and Mary …… | 1689—1702 | 13 | 106 | above 8 |
| Anne …… | 1702—1714 | 12 | 29 | nearly $2\frac{1}{2}$ |
| George 1st …… | 1714—1727 | 13 | 97 | $7\frac{6}{7}$ |
| George 2nd …… | 1727—1760 | 33 | 263 | 8 |
| George 3rd …… | 1760—1820 | 60 | 3,766 | $62\frac{3}{4}$ |
| George 4th …… | 1820—1830 | 10 | 1,535 | $153\frac{1}{2}$ |
| William 4th…… | 1830—1837 | 7 | 1,467 | nearly $208\frac{1}{2}$ |
| Victoria…… | 1837—1852 | 5 | 6,833 | above 455 |

Under the New Law, commencing October 1852.

October 1852 to December 1852—1,211 Patents for three months.
January to „ 1853—3,045 „ per ann.
1854—2,764 „ „
1855—2,958 „ „

The conclusions we draw from these facts are, that excessive patent fees are a serious tax on the inventive ingenuity of the country; that it is questionable whether any distinction should be made between large and small inventions so long as they are original and useful; and lastly, that patent laws require and are capable of being amended. It is very certain that patent monopoly has largely assisted in encouraging the developement of an amazing amount of ingenuity in producing entirely new sources of industry, and in extending and improving many old manufactures.

Among industrial arts, husbandry is much indebted for machines which a quarter of a century back it would have been thought impossible ever to realise. And among manufactures, how many entirely new ones have arisen which we may reasonably trace to the direct operation of patent monopoly in the security it gives the capitalist for the safe outlay of his money on what otherwise would never excite his attention, and most likely only be treated as a wild, hopeless speculation. Among these patented inventions we trace the large manufactures of mackintosh cloth, Vulcanised India-rubber, gutta-percha, new dyes, felted carpets, gas, electric telegraphs, electroplating, stereotype printing, iron shipbuilding, wire rope, railway bars and locomotives, alpaca manufacture, photography, paraffine oil, with many more, all springing out of the security given for the investment of capital in the working of patent property.

The vast increase of improvements in husbandry, brewing, dyeing, printing, electro-plating, metallurgy, and other extensive operations, has called into exercise such a demand for scientific and skilled labour, that laboratories form an essential feature of many large establishments to test accuracy of production, exactness in important details, to seize any accidental suggestions that may offer, and to further scientific applications derived from independent sources. The entire circle of arts and manufactures is thus being constantly improved, and scientific research materially upheld and encouraged.

Still, there may exist individuals who seriously believe, and that without the slightest bias from self-interest or disappointed hopes, or any flush of success that renders them independent of adverse opinions to the means which achieved their own rise in fortune, that all the encouragement, improvement, and progress we have pointed out would have gone on all the same had Patent Laws never existed; and, in short, that all our distinguished patentees from Watt in 1769-1785, to the present times would have laboured, and produced, and laid out capital experimentally and practically, just the same had these patent laws been abolished; indeed, that Mr. Boulton would have been as secure and as successful without, as he was with patent monopoly. Such reasoners always assume that inventors invent from the pure unalloyed pleasure they take in reforming all existing systems of manufacture. Poets and prose writers may invent with a view to something more substantial than fame and honour, but mechanical inventors, we are to believe, are men far above the temptation of lucre!

In conclusion, and in contrast to any such idle dreams, we have the facts before us that all the patents preceding the eighteenth century were secret inventions, although an inventor had it in his power safely to communicate as much as he pleased to a manufacturer; and the consequence has been that few of those early inventions have come down to the knowledge of the present century: consequently, manufactures progressed slowly. When, later in the eighteenth century, patents came to be fully described, enterprise and competition gradually sprang up, until, at the present period the number of patents annually obtained has risen nearly 30 per cent. on the amount of those during the reign of George III. Therefore, patents are decidedly an evidence of commercial, manufacturing, and scientific growth and prosperity. A patent is the inventor's sheet anchor—it is his mainstay, which the more we improve and strengthen, the more shall we advance the prosperity of Great Britain and Ireland. A patented invention is for a cheaper article, or cheaper process, or an entirely new and untried branch of industry. No patented invention makes any article of manufacture dearer than it is at present; for it would not receive encouragement if it could be shown to be neither better nor cheaper than the ordinary manufactured goods. The million—the public at large, have no direct interests in patents as patents; the public interest is indirect, being concerned only in the products of the new manufacture. The interest of the public is in being able to purchase lace for 1s. or 6d. which had previously been sold as high as five guineas for equal quantities; and whoever attempts to argue against patent monopoly will have to show that science is independent of manufacturing interests for its encouragement, and that the progress of manufactures has been trammelled by patent monopoly; or that just the same or greater progress would have been made, had the world never known such patentees as those whose names and inventions have become almost as household words.

No. 2.—Distinguished Patentees under the Old Patent Laws ending October, 1852.

| | | | | |
|---|---|---|---|---|
| James Watt............ | 5 | Patents, for | steam-engines, dating ......... | 1769—1785 |
| Joseph Bramah ...... | 18 | „ | Locks, paper, &c. .................. | 1778—1814 |
| Archibald, Earl of Dundonald ......... | 11 | „ | Rotatory Engines, &c. ........... | 1781—1851 |
| Henry Cort ............ | 2 | „ | Iron Manufacture ................. | 1783—1784 |
| Mark Isambard Brunell | 8 | „ | Circular Saws, &c. ................ | 1799—1825 |
| David & Robert Mushet | 8 | „ | Iron Manufacture ................. | 1800—1845 |
| Henry Fourdrinier ... | 3 | „ | Paper Manufacture ............... | 1806—1840 |
| John Heathcoat ...... | 24 | „ | Lace Manufacture ................. | 1808—1843 |
| William Palmer ...... | 29 | „ | Candles, Lamps, &c. ............... | 1812—1852 |
| Jacob Perkins ......... | 19 | „ | Generating Steam, &c. ........... | 1819—1836 |
| Richard Roberts ...... | 17 | „ | Steam Engines, &c. ............... | 1822—1852 |
| Andrew Smith......... | 18 | „ | Wire Rope, &c., &c. ............... | 1827—1849 |
| David Napier ......... | 13 | „ | Propelling, generating steam, &c. | 1828—1851 |
| Charles Wheatstone | 7 | „ | Electric Telegraphs, &c. ......... | 1829—1845 |
| Henry Bessemer ...... | 21 | „ | Bronze, Glass, Sugar, Steel, &c. | 1838—1852 |
| James Murdock ...... | 15 | „ | Gas, Engines, &c. .................. | 1839—1852 |

In the course of the discussion which followed the reading of my paper at the Norwich meeting, Professor Leone Levi produced a paper written by Mr. Bell Galloway on the cognate subject of Inventors and Inventions. The substance of the paper was a proposal that the amount now in the hands of the Patent Law Commissioners, arising out of the fees charged for patents, should be used as a fund for the reward of inventors of useful inventions. Mr. Galloway estimated that there was about a million of money in the hands of the Patent Law Commissioners, the accumulation from year to year of the fees paid by inventors.

Mr. Bramwell, C.E., said he wished to say a great many words upon this subject, but he knew that as this was the last meeting of the Section, it was the duty of those who spoke to be as brief as possible. Otherwise the magnitude of the subject deserved serious consideration, for he firmly believed that there was none that could be brought before the Statistical Section that went more immediately to the progress of the country in manufacture and arts than the question of the patent laws. They had had the advantage of hearing on this occasion a paper read by a gentleman who was thoroughly conversant with the subject. Such papers were not always written by those who were conversant with the subject, but by literary men who expected to be able to understand mechanics from seeing a piece of machinery in action. These gentlemen assumed that manufacturers are eager to take up improvements. But he knew as a fact that manufacturers were very averse from taking up an improvement, for two very obvious reasons—one being a sort of offence that you feel at having a man coming and telling you that he knew your business better than yourself. Another reason was a question of pocket. A manufacturer has got a sum of money embarked in machinery to carry on the old modes, and naturally enough he is not willing to throw off all that aside as useless, and embark fresh capital in the adoption of new modes of manufacture. Those who watched the working of the patent laws know that the difficulty is not with the commerce to get the invention, but with the inventor to get the commerce to use it. Unless by some plan or another you made it worth the while of the inventor to go to the manufacturers, and, to use a common saying, thrust his invention down their throats, he did not hesitate to say that you would not get these inventions adopted. The secretary had read the results of a paper which propounded one of these schemes. Those who were adverse to patents owned that inventors should have some rewards, and this proposition of Mr. Bell Galloway was one of them. He thought the paper was based on a wrong assumption—the assumption that there was a million in the hands of the Commissioners. He thought there was nothing of the kind; he believed the annual surplus was something like £30,000 or £40,000, and that it was appropriated year by year to the ordinary revenue of the country. Then it was said the inventor might be rewarded in this obvious manner—let him become the manufacturer of the thing that he has invented! and as he would know best how to carry out his invention, surely he would have the preference over every other manufacturer, and that preference would be sufficient to reward him. He could not help thinking that those who put that view forward were really not acquainted with the working of inventions. If a man who manufactured carpets improved the manufacture of carpets, it might be that he could reward himself by pushing his invention. But the large substantive inventions were made by persons not in the manufacture, but outside the particular manufacture. For this very obvious reason: if a man was apprenticed to a particular calling, he was brought up with certain views and ideas; he makes inventions for improvements in detail; he does not look at the matter from a totally new point of view, and thereby makes a substantive invention. Take Watt as an instance. Watt was not a steam-engine maker: he was a maker of mathematical instruments. Bessemer was not a metallurgist; he was a maker of bronze powder. Take Brown, the inventor of the fish-joint—he was not an engineer; he was a railway-carriage builder. Then, supposing a man had made an invention in a substantive manner, how was he to carry it out? He had no trade connexion, perhaps he had not the ability to command workmen, perhaps he had got no capital. And yet they were told the way that man was to reward himself was to go and manufacture the thing he had invented. There were many cases in which the thing did not admit of any special manufacture. Take the case of the fish-joint. It consisted of two pieces of iron bolted to the end of the rail which you wished to join. Those two pieces of iron could be made by any manufacturer of iron. In what way could the inventor of the fish-joint reward himself by making fish-joints? He was a man living in London, and he would be beaten by any ironmaster in Wales. Again, taking Siemens' furnace; that could be made by any common bricklayer from drawings. Was Mr. Siemens to turn bricklayer? and how was he to compete with bricklayers who had been brought up to the trade from their boyhood? Then it was said there ought to be a species of Government reward. Could anyone imagine anything more prolific of jobs than a Government reward for inventions? The persons who had to adjudge those rewards would be the best-abused people in the world, and probably in sheer despair they would go wrong. Then there was the secret manufacture, upon which the writer of the paper so ably touched. Now, Crompton was the inventor of the spinning mule, a great improvement in making yarn. He took out no patent, he worked in his own building, in the Hall in the Woods, as it was called; and there in secret he made his yarn. He brought it to market; it was preferred to all other yarn. It was sold in large quantities, as fast as he could make it with his own hands. When it was found to be so good, people were employed to go up into the trees and look in at the windows, to scale the windows by ladders. He had to board up the windows and to work by light got through a skylight. Then he got his own family to help him, and his very children were taken from him by bribery by the neighbouring manufacturers. At last the manufacturers agreed, if he would divulge his invention, to pay him a certain sum. It was on record that only two of those men fulfilled their engagement. He then took a workmen when the thing was public, but he never could keep a man. As soon as a workman had been with him a few months he went to some one else, and said he had been with Crompton, and he immediately got employment at better wages. In reality, Crompton then became a schoolmaster to teach his invention to others; at last he got a Parliamentary reward of £5,000.

Mr. Tomlinson said one of the evils of the present system was the indiscriminate manner in which patents were granted. People obtained patents to the number of something like 3,000 a-year, the great part of which were mere obstructions to industry, science, and art. Anyone who read the last Report of the Commissioners of the Patents would be amazed at the enormous amount of fraud, iniquity, and vexatious legal proceedings consequent on the indiscriminate manner in which these patents were granted. As an instance in which these patents were obtained, he would mention the case of a tailor, who, having received an order to make some alterations in the caps of a regiment, at once patented the altered cap; so that if the Government had required similar caps for the whole army, they must have gone to that tailor for the entire supply.* Probably the 3,000 persons who obtained patents every year, not above six or ten of them had invented anything which was of any real value.

## INSTITUTION OF CIVIL ENGINEERS.

### THE CONVERSAZIONE.

The President, Mr. C. H. Gregory, received the members of the Institution of Civil Engineers and their friends on the 25th of May at a *conversazione*, given by him in the new building in Great George-street. In spite of the vastly increased accommodation, the number of visitors was so great that it was evident that the new building had not been constructed upon too grand a scale. As many of our readers may not have had an opportunity of seeing the new house the following particulars respecting it may be of interest. The lecture room has a clear area of 60ft. by 40ft., with a height of 30ft. to the springing of the dome, which affords the means of lighting the room. The arrangements in the room are very complete, the seats being very comfortable, the means of ingress and egress very ample, the heating, ventilation, and lighting remarkably good, while the taste with which the room is decorated, reflects great credit upon Mr. J. H. Wright the architect. Besides this noble room there is the library, 42ft. by 28ft.; the reading and writing room 40ft. by 28ft. 4½in.; the secretary's room 24ft. by 17ft., and the clerks office 17ft. long by 16ft. wide. The warming apparatus, for the lecture room, consists of a fan 3ft. diameter, driven by a small gas engine, and calculated to be equal to supplying 400,000 cubic feet of air per hour, which is equal to 800 cubic feet per hour for each person, when the room is full.

The exhibits in the large lecture room were so numerous that it would be impossible to do justice to all of them. Some of the most striking were the models of marine engineering, consisting of representations of the engines of the *Minotaur* and *Northumberland* by Messrs. Penn; also a model of the engines of the *Agincourt* by Messrs. Maudslay, and models of the engines of the *Lord Clyde*, and the Irish Mail Packets, *Leinster* and *Connaught* by Messrs. Ravenhill These were all kept in motion by means of a shaft running along the floor line, and driven by the gas engine belonging to the institution. Another model connected with marine engineering, consisted in a very simple contrivance, by Major General Morris of the U.S. army, for disengaging ships boats, and which we understand is already adopted in the steamers belonging to the North German Lloyds, and is also being applied to various other steam vessels.

There was also a very handsome model contributed by Admiral Halsted, of a dispatch vessel, and a cutter and launch in steel; also a turret by Napier, and a Heathorn muzzle pivoting gun carriage. A very beautiful model was contributed by Mr. Rendel, of the gunboat *Staunch*, which has already been noticed in these pages. Since that time she has been constantly tried and has given every satisfaction. The 12½ ton gun with which she is fitted has also been frequently fired, and it is the opinion of the naval authorities that this class of vessel would be very efficient for coast and harbour defence. The Thames Iron Works Company contributed a model of the *Volage*—the first of a new class of fast skirmishing vessels. She is 270ft. long and 42ft. beam; the engines are 600 horse power nominal, by Messrs. John Penn and Son, and the armament consists of six 6½ ton guns and 64 pounders fore and aft.

Mrs. Vansittart exhibited several models of the Lowe-Vansittart propeller, illustrating the various steps by means of which the propeller has arrived at its present form. A model of a new life boat by Mr. Whithers was shown, in which cylindrical air chambers are fitted in recesses in the sides of the boat to increase its buoyancy. These chambers can also be turned outwards, to form outriggers, when it is required to increase the stability of the boat.

In railways and rolling-stock there were a great many exhibits. Mr. Robert Fairlie contributed a small model of an engine just built at the Hatcham Iron Works upon the system he has so strenously and persistently advocated, and which has just had a very successful trial. Mr. Beattie, the engineer to the South Western Railway, sent two of his patent equilibrium slide valves, which have seen a great deal of service; also some well worn bearings. These posessed peculiar interest as being examples of successful railway practice.

Mr. William Austin exhibited his invention for a means of communication between the passengers and guards of a railway train. This consists of an ordinary speaking tube extending through the train with a peculiar method of making the couplings, which appears to be very simple and good.

Mr. Price Williams contributed a beautiful model of his improved switches and continuous crossings, which appear to be embody some important improvements over the present system. These switches are furnished with Deas and Rapier's indicators, which locks the signals to danger while the switch is being moved and only permits their motion when the switch is in position. Mr. Rapier also exhibited one of his patent signal posts, which is especially designed for being sent abroad. It consists of three wrought iron tubes connected together at intervals by triangular framing, thus forming a strong, simple, and light post at a moderate cost, but the chief advantage seems to consist in the small bulk it occupies when packed for shipment. A complete signal post on this system 70ft. high was shown packed up, and it only occupied a space of about 12ft. long by 9 or 10in. in diameter.

Messrs. Ransom exhibited models of their continuous railway crossings, in which Mr. Price Williams' grooved rail is employed in connection with a casting which forms the siding. This appears to be a very simple and cheap crossing.

There were two models illustrating separate contrivances for working with a mid-rail upon mountainous lines. One was by Mr. Edward Barnes, of the Cenis Railway, and the other by Mr. A. Alexander, also of Mont Cenis celebrity. Both of these models appeared very ingenious, though we fear the various modifications are scarcely in the right direction. A length of Mr. Ashcroft's compound rail, similar to that now in use on the Charing Cross line, was exhibited. A peculiar fish-joint was shown by Mr. Gregory, consisting of two plates fitted to each side of the rail in the usual manner, and bent round so as to meet beneath the rail in the centre, where the plates are curved outwards and a clip is slipped over them to hold them together. Mr. Doering also exhibited a system of fastening rails by means of elastic steel clips, keys, and trenails, and Mr. Livesey showed his system of wrought-iron sleepers for the permanent way. Lea's system of locking railway gates at level crossings was exhibited by Col. Hamilton, by means of which the signals so act upon the gates that they cannot be opened unless the line is blocked by the signals being placed at danger. Amongst other contrivauces connected with railways may be mentioned Messrs.

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* This is obviously a mistake. The tailor not being the true and original inventor, his patent would not be valid; besides, the Government is not liable to pay for using any invention they choose.—ED. ARTIZAN.

Thomson and Browning's wrought-iron fencing for the Indian railways and Messrs. Muir and McIlwbam's wrought-iron coiled keys for railway fastenings. Two designs for equilibrium slide valves were contributed; one being Mr. Outridge's patent, and the other by Mr. Church, whose exhibit had been running for some time on the Great Northern Railway. Mr. Fidler's articulated rolling stock was worth attention, as it appeared to give great flexibility to the train, though it might possibly be objected that, in the case of a broken axle, the damage would be more serious than with the present system. The wire-rope tramway, by Mr. C. Hodgson, which has been found very successful in transporting stone or ore over difficult country, was well worthy of attention. This system consists in stretching an endless rope from post to post placed at regular intervals across the country to be traversed. This rope runs on wheels fixed to the posts, and is driven by means of a Fowler's clip drum; buckets carrying the material being hung upon the rope at certain distances apart, affording the means of conveyance. There were many ingenious contrivances for removing and replacing the buckets without stopping the rope, also for shunting at each end. Altogether this system promises to be of great value in rough countries. or where the traffic is not sufficiently large to support a railway.

Various other interesting exhibits found a place in the building, such as the beautiful models contributed by Col. Clarke, one of which, the sliding caisson for the entrance of the basin of the navy yard at Haulbowline, Cork, appeared to be remarkably simple an efficient. In connection with the same subject, Col. Clarke exhibited a model of a caisson for a dock at French Creek, Malta, and also a very fine large working model of a sliding caisson for Portsmouth dockyard, which is being made by Messrs. Easton, Amos, and Anderson. The opening for which this caisson is intended is 80ft. wide and 38ft. 6in. in depth below the coping; the depth of water at high tide is 29ft. 9in.; the width of the caisson, 12ft. 1½in., and its weight when ballasted is 294 tons.

Mr. Bartholomew, of Leeds, contributed excellent models of a steam-train for canals, and a hydraulic hoist to be used in conjunction with it. The steam train consists of a series of articulations hinged together by central couplings, so as to form a flexible line. By disconnecting the hinges these sections, as they are brought under the hoist can be lifted up out of the water and their contents discharged.

Mr. Baldwin Latham exhibited a model of a very ingenious apparatus for separating solid matters from sewage, one-sixth the full size of a machine now being made for Croydon. It consists of a large vertical wheel placed in a chamber, the bottom of which is a little below the bottom of the sewer, and the axle of the wheel being in the same plane as that of the sewer. Upon this wheel perforated diaphragms or grids are fitted of different degrees of fineness, arranged in two planes parallel to each other, and filling up the open spaces between the arms of the wheel; brushes rest against the outer plane for the purpose of removing any solid matter that may adhere. There are also radial elevators which stretch like spokes from the centre of the wheel to these screens, and which are made the full width of the wheel. The floors of these elevators are made of flat bars, hinged at both ends, so that they are free to swing with their own weight. These hinges are so placed that when the bars are at the lowest point of their revolution, the spaces are widest; these spaces gradually diminishing as the wheel revolves, until they form an uninterrupted inclined plane, when they shoot their contents into a small chamber, formed like an archimedean screw round the axis of the wheel, for the purpose of removal. A small tray is placed just inside the rim of the wheel at the end of each elevator, weighted so as to tilt when at a sufficient inclination, the water it contains washing down the solid particles that may adhere. The whole arrangement appears very complete, and well calculated to perform the duty assigned to it.

Several steam pumps were exhibited, amongst which may be mentioned the "Paragon" pump by Messrs. Kittoe and Brotherhood; a nicely arranged pump by Mr. Tijou and one of Messrs. Tangye's "special" pumps. The last named firm had also models of various useful "notions" such as hydraulic jacks, ramps for replacing carriages which have got off the line, duplex lever punches, &c. An excellent working model of an American steam pump was also exhibited by Messrs. Hayward, Tyler and Co., the manufacturers.

Messrs. J. and H. Gwynne of the Hammersmith Ironworks, contributed one of their well-known centrifugal pumps; although it was the smallest size made by them, the cylinder being only 3½in. in diameter, and 3½in. stroke, it is said to be capable of discharging from 80 to 100 gallons per minute to a height of 80ft. In order to accomplish this amount of work it is driven at the rate of 850 strokes per minute, a rate of speed that nothing but the highest excellence in workmanship, such as was shown in the present case, would stand for any length of time. The same firm also contributed a pretty little working model of their patent centrifugal pump which has already been noticed in the Artizan.

A remarkably ingenious instrument called the Automaton Alcoholometer was sent by Mr. Robert Sabine. The object of this apparatus is that of measuring spirit for the purpose of taxation as it leaves the still, much in the same way as a gas-meter measures gas as it enters our houses. The invention of this highly ingenious apparatus is due to Dr. Siemens, the celebrated physicist, of Berlin; and the way in which the details of design and construction have been carried out is very beautiful and perfect. As the spirit—no matter of what strength—leaves the still, it passes into a cylindrical vessel, and from this, through a drum—something like that of an ordinary gas-meter—into the cask which is to contain it. On its way through the apparatus it is measured, gauged, and registered with the greatest possible exactness. First, its bulk or volume is measured and indicated, in gallons and decimal parts; and secondly, the quantity of either absolute alcohol or of proof spirit which it contains is measured and indicated independently. The measurement and registration of the total bulk or quantity of spirit which passes over is obviously done directly by the rotation of the drum, each of the three divisions of which holds exactly five gallons. The indication of the strength of the spirit is done by a swimmer in the cylindrical vessel into which the alcohol first enters as it leaves the still. This swimmer is attached to a pointer, which, in being elevated and depressed by the lowering or rising of the swimmer, according to the varying specific gravity of the liquid, limits the reciprocating movements of a graduated tongue in connection with the counter work. Thus, not only do the distiller and the exciseman know at a glance how much spirit, in total, has been distilled within a given time, but likewise how much proof spirit it is equivalent to.

Apparatus of this kind are about to be introduced into practice in many of the continental states. The obvious advantage which follows its use is that, as the machine indicates authentically, the excise official has nothing to do but to read off and write down occasionally its indications, thus saving all gauging, weighing, and calculating. It is estimated that twenty excisemen could—were this apparatus in general use—do more work, and do it more efficiently, than a hundred of them with the present system.

Messrs. Bryan, Donkin, & Co., exhibited an apparatus designed by Mr. Farcy and Mr. Donkin, jun., for measuring and registering the temperature and quantity of water passing from the hot well of an engine. By this means the amount of heat discharged per indicated horse-power may be ascertained and the performance of the engine judged therefrom.

A large number of philosophical and electrical apparatus were exhibited, amongst which may be noticed Capt. Albini's self-registering compass, by Messrs. Elliot Brothers, an ingenious arrangement for keeping a continuous record of the course steered by the ship. Messrs. Beck contributed examples of their barograph, thermograph and anemograph as adopted by the Meteorological Department. The latter instrument does not appear to be new; in the case of the barograph and thermograph, however, the registration is performed by means of photography, the paper on the revolving drum being sensitized and a pencil of light passing through a slit being used instead of a material pencil, as in the case of the anemograph, Mr. E. T. Loseby, of Leicester, exhibited a Maury barometer, which appeared very similar to the Aneroid, but is said to be more delicate. Mr. F. W. Reynolds exhibited his "Palinurus," a description of which was lately given in The Artizan. Mr. W. Hurst, jun., exhibited a very ingenious clock to be regulated by electricity, and which was constructed by Mr. Harrison. His clock is maintained by a spring, and has a second train of wheelwork by which the hands—both hours, minute, and second hands—are, upon the release of a detent by means of an electro-magnet, set to the exact hour next preceding or following the time indicated by the hands, at the moment the current passes. Thus a periodical current from some well-regulated clock needs only to be given at any full hour, in order to keep any number of Harrison's clocks perfectly right. The advantage of this method is that the movements of the clock being entirely independent of the electric current, should the latter be interrupted the clock goes on all the same, only accumulating whatever error may be due to its rate. The electric fire-alarm shown by Mr. Sax is ingenious; an india-rubber bag, filled with air, is so placed that when heated by the fire the air expands, and forces a metallic lever against a contact point which closes the circuit of an electric bell.

A great number of other interesting objects were exhibited, but want of space prevents us from noticing them at present. A description of some of these, however, we hope to give in a future number of The Artizan.

## INSTITUTION OF ENGINEERS IN SCOTLAND.

### ON BOUSSARD AND BARIQUAND'S MODERATEUR PARABOLIQUE AND MORTON'S GOVERNOR.

By Mr. James R. Napier, F.R.S.

It is well known that the conical pendulum or ball governor, so long used in connection with steam engines, increases its angular velocity, as the engine itself has less work to perform; while the object of the governor is to compel the engine to go at an uniform speed, at whatever rate the load on the engine may be increased or diminished. Many attempts have been made to produce this isochronous motion, but few governors involving this principle have come into general use. Sir William Thomson having called attention to the subject, the writer has noticed a short paper in a work recently presented to our Institution by our French friends the Société des Anciens Elèves des Ecoles Impériales d' Arts et Métiérs, describing a very simple isochronous governor by Boussard and Bariquand; and since then he has seen a still simpler form on the same principle, by Mr. Morton, of Ejector-Condenser notoriety.

Mr. Morton makes the balls travel in a parabolic arc, and as the resultant of gravity and centrifugal force on them is a normal to the curve, the subnormal of which is constant, it follows that the angular velocity would be uniform, if friction did not interfere.

The balls themselves are each two half balls (see accompanying engraving fig 1) which roll on a parabolic rail—the axle between the half balls passing through a horizontal slot in a frame connected with the valve rod, dispenses with the ball rod and hinge—nothing could be more simple. In Boussard and Bariquand's system, Fig. 2, the balls, besides being fixed to arms and hinged as in ordinary governors, have each an axle through their centre, on which are a pair of little wheels which carry the balls up or down a pair of parabolic rails like a carriage on a railway —the frame to which the arms are hinged sliding up or down on the axis and in connection with the valve rod.

Let S = the space in feet between the plane of revolution and that point in the parabola intersected by the axis—then; $v = \sqrt{S \times 64.33}$, $v$ being the velocity ,in feet per second when the force of gravity equals that of the centrifugal force. When the balls are revolving in the lesser circumference, GLD, the space S is $2\frac{1}{2}$in., or 0·2083ft., and when they revolve in the larger circumference the space S is 10in. or 0·832ft. Therefore

$$3{\cdot}66 = \sqrt{0{\cdot}2083 \times 64{\cdot}33}.$$

and

$$7{\cdot}32 = \sqrt{0{\cdot}832 \times 64{\cdot}33}.$$

The lesser circumference, G L D, is 2·618ft, and the greater circumference, H M E, is 5·236ft. Consequently

$$\frac{3{\cdot}66}{2{\cdot}618} = 1{\cdot}399$$

$$\frac{7{\cdot}32}{5{\cdot}236} = 1.399$$

$$1{\cdot}399 \times 60 \text{ seconds} = 83{\cdot}9 \text{ revolutions per minute.}$$

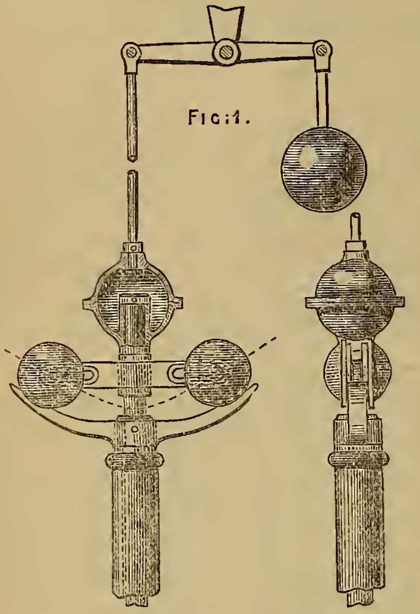

FIG:1.

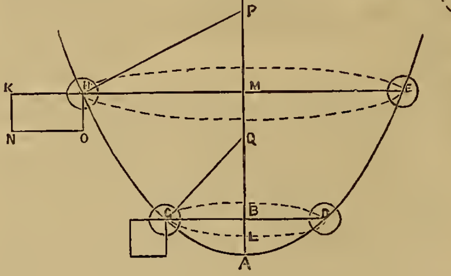

FIG:3.

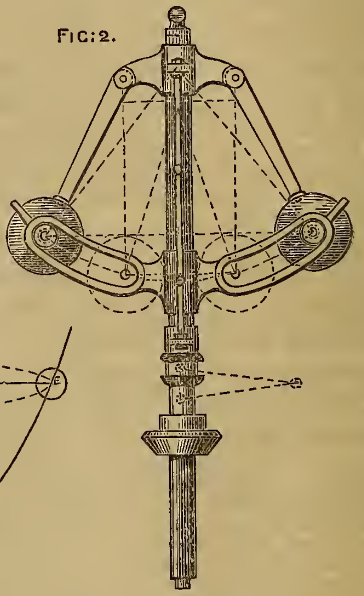

FIG:2.

M. Boussard says of their "Moderateur Parabolique"—"During a period of five months, we have experimented on a governor of this kind on a horizontal engine of 10 horse, and the results at which we have arrived are exceedingly remarkable. The number of turns of the machine has always been $60\frac{1}{2}$ per minute, notwithstanding the sudden variations of 5 to 10 horse in the work transmitted. The machine was calculated for working at 60 turns; this difference ought only to be attributed to a slight want of weight in the balls. We think that till now no regulator has approached so near to perfect regularity.

The writer has no doubt that Mr. Morton can give as favourable a report of those he has fitted up.

Mr. Alexander Morton in explanation said, the paper just read comparing the governor of M. Boussard and Bariquand with that designed by him, originated through a visit Mr. J. R. Napier made to the works of Messrs. Neilson Brothers for the purpose of experimenting on the "Ejector-Condenser." During the visit he noticed some of these little governors which were designed more for economy in first cost than any perfection in their application, but as he was just on the eve of going abroad the subject did not receive so much of his attention as he could have wished, hence, the brevity of his paper; however, he wrote from Liverpool requesting that some experiments should be made prior to the reading of his paper, as he was confident that the results would be deserving of discussion, and that the principle was mathematically correct. In the experiments which the writer has made with the governor, Fig. 1, the weight of the sliding collar with its cross slides was accurately balanced by the weight attached to an overhead lever of equal lengths, so that the balls were free to rise so soon as the centrifugal force overcame that of gravity in them, and when at a constant speed of 84 revolutions per minute, and with the slightest touch of any of the connections with the sliding collar, so as to change the position of the balls on the parabolic curve, they would remain (floating as it were), until the number of revolutions varied, and two revolutions, more, or less, caused the balls to rise, or fall (all at once) through the limits of their range. This governor was not constructed with the nicety of workmanship such experiments would deserve, and as the friction could be considerably reduced by introducing small rollers in the cross slides, having the axis of the balls for their centres, and the weight of the balls increased, better results may be hoped for. Calculations made in accordance with the parabola shown in Fig. 3, are here annexed.

## LONDON ASSOCIATION OF FOREMEN ENGINEERS.

A well attended meeting of this rapidly growing institution took place on Saturday the 5th ult., at the City Terminus Hotel. The chair was filled by the president, Mr. J. Newton, of the Royal Mint, and the vice-chair by Mr. John Ives. As usual, the election of new associates, honorary and ordinary, preceded the immediate business of the sitting. Mr. Fergus Jordan, of Messrs. McGlashan's, Victoria Works, Drury-lane; Mr. Samuel Goddard, of Woolwich Arsenal; and Mr. John Hooden, also of Woolwich Arsenal; and Mr. Welch, of Messrs. Ravenhill and Co.'s, as ordinary members, and Mr. N. H. Allan, of Messrs. Gwynne's, and Mr. W. Whieldon, of the firm of Whieldon, Lecky, and Lucas, as honorary associates were unanimously elected.

Mr. David Walker then proceeded to read a paper on the "Simplification of the Patent Laws." After defining what patent rights really mean, the author traced at considerable length and with great lucidity, the history of the patent system from the time of Queen Elizabeth to the present hour. He combated the views of Mr. Macfie, Sir Roundell Palmer, Lord Stanley and others who took part in a recent debate on the abolition of the patent laws in the House of Commons, and declared himself in favour of a sweeping amendment of the patent system, but quite opposed to abolition. Mr. Walker considered the principal evils of the present law of patents to consist in—(1) The exorbitant cost of a patent; (2) the imperfect security it afforded to an inventor; (3) the litigation which its maintenance entailed; and (4) the cumbersome and vexatious nature of the legal machinery for settling disputed questions affecting patent rights. The first demand he would make was, that the original cost of a patent should be reduced to a sum not exceeding what was absolutely necessary to cover legitimate expenses. In the next place, there should be appointed a competent body of skilled men, whose characters were above reproach, and who should be empowered to judge of the merits or defects of an invention, and decide as to whether it was a proper subject for a patent or otherwise. He would also recommend that a special tribunal should be established for deciding disputed questions of patent right. Common juries, as a rule, were quite inadequate to this task. Finally, he would ask that, as the rights of authors and inventors were absolutely analogous, so the laws relating to invention should be assimilated as closely as possible to those of copyright. These points, the reader of the paper maintained, were of vital importance, and when they were gained the simplification of the British patent law would be an accomplished fact. The foregoing constitutes the barest possible summary of Mr. Walker's elaborate, and, it may be allowed, eloquent contribution, to the proceedings. It was followed by a very spirited discussion, shared in by Messrs. Humes, Thorburn, Irvine, Bragg, Muir, Shotton, Ives, Vinicombe, and others, the feeling expressed by all being favourable to the reformation, rather than the destruction of the patent system. In fact, it was manifest that the meeting was unanimously of this way of thinking. In putting the usual vote of thanks as a compliment to the author of the paper, Mr. Newton took occasion to say that he hoped another Royal Commission would ere long be nominated to examine into the whole subject of patents at home and abroad. By comparing the various systems at work throughout Europe—and notably in the United States of America—with that in force in this country, data might be obtained which would be of service to the Legislature in amending our own admittedly defective patent laws. For himself, he was exceedingly glad that the question had been ventilated at a meeting such as theirs, because every member was a practical man, and most of them had actual experience of the evils they deprecated. Certainly opinions thus formed were worthy of consideration, and they had been expressed in such a manner as would show that the interests of all classes of the mechanical trades, and not of any one in particular, were recognized by the Associated Foremen Engineers. The vote was then passed by acclamation, and the sitting terminated.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON SOME FURTHER RESULTS OF SPECTRUM ANALYSIS AS APPLIED TO THE HEAVENLY BODIES.

By William Huggins, Esq., F.R.S.

The speaker commenced by saying that four years ago he had the honour to give in the theatre of the Royal Institution an account of the results of an attempt to apply the method of analysis by the prism, for which science is indebted to Kirchhoff, to the light of the heavenly bodies. It was the speaker's purpose to describe, on the present occasion, some of the results which had been obtained in his observatory since the spring of 1865. The peculiar suitability of spectrum analysis as a mode of investigation of the bright objects in the heavens had been confirmed, not only by the gain of further information of the chemical and physical constitution of some of these immensely distant bodies, but also by knowledge of another kind which this elegant and searching method of analysis had revealed to us. The speaker then described the three typical forms under which all spectra may be classed, and the interpretation which our present knowledge enables us to give of these different spectra when the light is emitted by bodies rendered luminous by heat, The spectra of fluorescent and phosphorescent bodies were not to be described.

1. A continuous spectrum without dark or bright lines shows, as a general rule, that the luminous source is in the solid or liquid state. In certain exceptional cases, however, a gas may give a spectrum which is apparently continuous. Dr. Balfour Stewart pointed out that as gases and vapours possess a power of general absorption, in addition to the selective absorption peculiar to each gas, a gas when luminous would emit light of all refrangibilities, producing a continuous spectrum, would be in proportion to the opacity of the gas. The researches of Plücker and Frankland have shown that under certain conditions of density and temperature, the bright lines of hydrogen expand so as to produce a spectrum which is apparently continuous. 2. A spectrum of bright lines indicates that the luminous body is in the state of gas. Each gas and vapour has its own set of lines. The lines may be greatly modified, or even altogether changed, under different conditions of temperature and density, as is well known in the case of nitrogen, the vapour of sulphur, and some other substances; but throughout all these changes each gas behaves in a way peculiar to itself. There appears to be one exception to the statement that a spectrum of bright lines is peculiar to luminous gas. Bunsen found that when solid erbia is heated to incandescence, the continuous spectrum contains bright bands. 3. A continuous spectrum interrupted by dark lines informs us that the light has passed through vapours at a lower temperature than the source of light. As the kinds of light absorbed by each vapour correspond precisely with the set of bright lines which that vapour emits when in the luminous state, it is possible to learn if the vapours are those of any of the substances with which we are acquainted.

The speaker said that following the arrangement adopted in the former discourse, the most important recent information obtained of the fixed stars results from the application of prismatic analysis in a new direction. Under certain conditions the spectrum of a luminous body is adapted to tell us whether that body is moving towards or from the earth. The importance of information on this point will be seen from the consideration that the proper motions of the stars represent that part only of their whole motion which is transverse to the line of sight; for any motion they might have in the visual direction, towards or from the earth, would not cause any visible displacement of the star, and could not therefore be ascertained by the ordinary methods of observation. As it is upon the length of the waves, or upon the number contained in the series that enters the eye, or falls upon the prism in a second, that a judgment is formed of the colour of the light, or its place in the spectrum is determined, it follows that any circumstance which would alter the lengths of the waves relatively to the observer, or, in other words, cause a large number of waves to enter the eye in a second of time, would cause a change in the colour or refrangibility of the light so far as the observer is concerned. It is obvious that if the observer advances to meet the light, a longer series of waves falls upon the retina in a second of time, each wave appears shorter, and he ascribes to the light a higher refrangibility than he would do if he were not advancing to meet the light. If he were receding from the star an alteration of refrangibility in the opposite direction would take place. The same effect would ensue, if the luminous source were in motion. Thus to a swimmer striking out from the shore, each wave appears shorter, and he passes a greater number of them in a given interval in proportion to his speed through the water. Illustrations were given of this principle, which was first suggested in 1841 by Doppler, by means of an analogous change of pitch in sound. Two tuning-forks sounding in unison were moved rapidly towards and from the audience, when beats were heard, which told of a difference of pitch produced by the opposite motions of the forks. As there exists beyond the visible spectrum, at both ends, a store of invisible waves, these would be advanced or degraded in visibility, in proportion as the colours of the spectrum were altered, and no change of colour would be perceived. It is therefore essential before we can apply this method to detect the radial motion of the stars, that we know the original refrangibility of some part of the light at the moment it left the star, and also that we are able to recognize this particular part of the light again in the spectrum of the star's light. When by means of a group of dark or bright lines we learn the presence of a terrestial substance in the star, both these conditions are fulfilled. Of all the stars which the speaker had compared with terrestial elements, when working with his distinguished friend Dr. W. A. Miller, Treas. R.S., Sirius, which contains four very strong lines which are due to hydrogen, appeared the most suitable for this investigation. The apparatus employed, and the special precautions which were taken to ensure the perfect coincidence in his instrument of the stellar lines with those of the substance compared with it, were described by the speaker, who stated that after a prolonged comparison, extending over many weeks, of the line of hydrogen in Sirius in the green, at the place of F in the solar spectrum, with the line of terrestial hydrogen, he found that the line in the star had undergone a shift in the spectrum equal to a difference of wave length, which would correspond to a motion of recession between the star and the earth of 41 miles per second. The speaker had obtained evidence from experiment that this shift was not due to unsymmetrical expansion of the line in hydrogen as the density is increased. The greater width of this line in Sirius than in the solar spectrum would show that the hydrogen in Sirius, though at a pressure considerably less than that of our atmosphere at the surface of the earth, is more dense than the hydrogen in the solar atmosphere by which the dark line F is produced. This conclusion is in accordance with the presumably enormous mass of Sirius, as suggested by its great intrinsic splendour. The earth at the time of observation was moving from Sirius at about 11 miles per second, which would leave 30 miles as due to the star. A further connection is required for the solar motion in space, which is believed to be towards Hercules, with a velocity of 4 or 5 miles per second. The whole of this must therefore be deducted, leaving about 26 miles as the motion of Sirius from the earth in the line of sight. The true motion of the star would consist of this radial motion compounded with the transverse motion of from 24 to 40 miles per second, which is shown by its proper motion.

The speaker then described a further examination of the nebulæ (about fifty have been successfully observed) with a more powerful spectroscope, which confirms his previous conclusion that these bodies consist mainly of the gases nitrogen and hydrogen. He also found that when the spectra of these gases are made faint by the removal of the spark to a distance, all the lines are extinguished with the exception of the one line in each spectrum which is found in the nebulæ. If such an extinction takes place in the case of the nebulæ, since they are objects of sensible size, it must be attributed to a power of extinction of light existing in cosmical space. Observations of four comets have been made. A large part of the light of these strange objects was found to be peculiar, and therefore emitted by the cometary matter. Brorsen's comet at its return in 1868, and a comet discovered by Winnecke, gave a spectrum of three bright bands. The spectrum of Winnecke's comet (comet II., 1868) was found to be identical with the spectrum of carbon as it appears when the induction spark is taken in olefiant gas, and in some other compounds of carbon. The spectrum of the comet was compared directly in the instrument with the spectrum of olefiant gas.

The speaker then described some observations of the sun. He found that while the solar lines are for the most part thickened when viewed in the light from the umbra of a spot, the lines C and F, due to hydrogen did not appear to be altered. This observation is of interest in connection with the constitution of the solar prominences as shown by the observations of the great eclipse of last August. The speaker nearly three years ago, at the same time that he had independently made attempts to see the prominences by means of the spectroscope, also tried the method of using absorbing media, by which the parts of the spectrum where the bright lines occur might remain, while all the rest of the spectrum was extinguished. In this way the faint prominences would be rendered visible, in consequence of the much greater relative diminution of the intensity of the illuminated screen of air, which on ordinary occasions conceals them from view. Recently he had succeeded in viewing the outline of these objects by means of a coloured glass combined with a spectroscope with a wide slit. He expected to be able to view these objects by means of coloured media alone.

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## ON THE COAST DEFENCES OF ENGLAND.

By Col. W. F. D. Jervois, R.E. C.B.

In bringing to your notice the subject for our consideration, I will first briefly refer to the coast defences of former times, and then endeavour to explain the principles of defence which are being adopted in this country at the present day.

In the earlier periods of English history our Anglo-Saxon forefathers were exposed to the frequent predatory incursions of the Northmen and the Danes, who, starting from the shores of Norway and Denmark, sailed round the coasts of England, ascended the navigable rivers, ravaged and laid waste the surrounding country, and then returned with their booty to their ships; and during the frequent wars waged by our Norman and Plantagenet kings with the sovereigns of France, the shores of England were subject to attacks by the French, which differed but little in character from the predatory incursions of the Northmen. The precautions taken by our ancestors to guard against such attacks are thus described by Holinshed:—"The custome of the countries adioining neere to the sea is, especiallie in time of warre, on euerie hill or high place to erect a beacon, with a great lanterne on the top, which may be seen and discerned a great space off, and when the noise is once bruted that the enimies approch neere the land, they suddenlie put fire in the lanterne, and make shouts and outcries from towne to towne and from village to village. Some run in post from place to place, admonishing the people to be readie to to resist the jeopardie and defend the perill. And by this policie the fame is soon blowne to euerie citie and towne, insomuch that as well the citizens as the rurall people be in short space assembled and armed to repell and put backe the newly arrived enimies."

But though these precautions sufficed to repel small predatory attacks, they were incapable of resisting anything like a national invasion; and the attacks of our foreign enemies were generally successful whenever they were made upon a sufficient scale. For instance, Dover was taken and partly burnt by the French under Montmorenci in 1296; and in 1339 the same nation took and sacked Portsmouth in retaliation for the English attack upon Boulogne. In the following year the French ravaged all the southern coasts of England during the absence of Edward III. in Flanders, destroyed several ships at Hastings, reduced the greater part of the town of Southampton to ashes, and burnt Plymouth nearly to the ground. In 1377, the French attacked the town of Rye and the Isle of Wight, and made great havoc at Hastings, Portsmouth, Dartmouth, and Plymouth; and three years later they pillaged Winchelsea, and several other towns. In 1405, a large French force was landed at Milford Haven, and before the army sent by our Henry IV. could reach the spot, the French had plundered Carmarthen and some other towns, and had safely regained their ships. Fortunately, however, the progress of civilization has introduced better usages into the practice of modern war, and it is not necessary now to provide against such plundering expeditions. In fact, the length of our coast is far too great, and the accessible points are far too numerous, to render it possible to fortify them all. When we speak then in the present day of our "Coast Defences," we must not be understood to advocate a vain attempt to secure by defensive works every vulnerable point; we mean to apply the term only to the means which it is necessary to provide for the protection of our national dockyards and arsenals, and of our main commercial ports.

We are sometimes told that the idea of fortifying these important points of our coasts is "un-English;" but if it be so, we ceased to be English some 330 years ago, when extensive fortifications were erected along our coasts by King Henry VIII. During the first years of that monarch's reign, his attention was attracted to the facility with which the French effected some landings on the coasts of Sussex. He had also been struck by the success of the French in their campaigns on the Continent in the fifteenth century, when their superiority in artillery turned the tide in their favour; and at a later period, when he had quarrelled with the Pope, he received information that the Roman Pontiff, at the instigation, as we read, "of Cardinall Pole, had moued and stirred divers great princes and potentates of Christendome to invade the realme of England." Thereon King Henry gave his anxious consideration to the question how best to fortify the most important points of the coast; and the steps he took for that purpose were such as might have been expected from his energetic character. He himself rode to inspect a considerable portion of the coast, sent his counsellors to survey all the ports and exposed places, caused forts and bulwarks to be erected, ordered general musters to be made, and armour and weapons to be "seen and viewed." Lord Herbert of Cherbury, in his life of Henry VIII., tells us that "all these preparations being made against a danger which was believed imminent, seemed so to excuse the King suppressing of the abbeys, as the people (willing to spare their own purses) began to suffer it easily, especially when they saw order taken for building divers forts and bulwarks on the sea coasts." In the State Papers, I find an interesting letter from Sir Antony Knyvet to the king, dated October, 1541, highly extolling the new fortress at Portsmouth, then recently erected; and begging the king to take an early opportunity of inspecting the plans of that great work; thus indicating that King Henry took a personal interest even in the details of his fortifications. The king's attention had previously been strongly drawn to the progress in the science of artillery. Mr. Froude, in his 'History of England,' observes that Henry VIII. was one of the first men to foresee and value the power of artillery; he tells us that Sebastiniani mentions experiments in the range of guns which were made by the king in Southampton Water; and he adds that "when the history of artillery is written, the labours of Henry VIII. in that department must not be forgotten."

During the reigns of Edward VI. and of Mary the subject of coast defence was almost entirely lost sight of. Not only was nothing done to extend, but scarcely anything was done to maintain the works constructed by King Henry. It was not until Queen Elizabeth came to the throne that public attention was again directed to the question. At this time (1559) England being actually at war with the second power in the world, the whole naval force in commission amounted to seven coastguard vessels—the largest of which was only of 120 tons—and of eight small merchant ships altered for fighting. Of ships in harbour fit for service there were but nine, of from 200 to 800 tons, with twelve sloops and boats. In artillery, the destitution was even more pitiable. Of cannon (48-pounders) and "demi-cannon" (24-pounders), in all the dockyards, there were but thirty which were reported sound, with 200 culverins (12-pounders), minions (3-pounders), and falconets. As for the troops, a certain Captain Turner, who was sent to command at Portsmouth, where he was in daily expectation of a visit from the French, reported to Cecil "that they were al grown to misorder and mischief, and to the greatest ill that man's head could imagine." There is a quaint letter written in 1587 by Lord Sussex to the Council, in which he complains among other things that the platform of the round tower at Portsmouth was so old and rotten that on the day of Her Majesty's coronation he "durst not shoot off the piece." The forts at Gravesend and Tilbury were in no better plight; for we find in a letter from Walsingham to Leicester, dated July, 1588 (the Armada almost in sight), that at Tilbury and Gravesend he could not find a single platform on the ground or aloft that was fit to bear any "ordinance." The country was, however, now aroused to a conviction of the necessity for taking active steps towards improving the state of the defences, and we now hear for the first time of a system of batteries for the defence of the Medway, and, a few years later, of permanent fortifications at Milford Haven. Orders were also given for the repair and arming of minor works at Rye, Eastbourne, Hastings, &c.

It would take too much of your time to dwell upon the measures for the minor improvement of our defences which were undertaken during the succeeding reigns; and I will pass on to the year 1666, when there was war with France, Denmark, and Holland, and when the House of Commons, to quote the words of Macaulay, "readily voted sums unexampled in our history" towards putting the country into a state of defence. This period appears especially interesting, as showing the course pursued when our fleet, as Macaulay describes it existed only upon paper, and when our enemies had the command of the sea. The chief engineer of this time, Sir Bernard de Gomme, was a man well fitted for such an emergency, and under his superintendence every effort was made to place the country in a state of defence. At Portsmouth, the old mud walls which had been constructed by King Henry VIII. had fallen into decay, and new lines were ordered and executed. The chief portion of the work, which is substantially the same as is now known as Portsmouth Lines, was completed in July, 1667. The lines of Gosport, which formerly only enclosed the town of Gosport itself, though designed and actually commenced at this time, were not completed for many years after. The fortifications of the Isle of Wight were jealously examined, and by the strenuous exertions of all concerned, the whole position was put into so excellent a state of defence, that we find by intercepted letters from the Dutch Admirals De Ruyter and De Witt, dated July, 1667—mark this—that they were deterred by the strength of Portsmouth and the Island from making their intended attack. At Plymouth the citadel on the Hoe was built, and at Dover, Weymouth, Dartmouth, and the Scilly Isles the fortifications were also strengthened. Sheerness was fortified now, and Pepys in his diary tells us that the king and the Duke of York went to Sheerness to see the ground which Sir Bernard de Gomme had staked out for the new fort there. The works, however, were not completed soon enough to prevent its guns being captured by the Dutch fleet under Admiral Ruyter in 1667, as they swept up the Medway to Chatham. The defences of Gravesend, Tilbury, and Woolwich, were also strengthened, and the city of London granted a loan of £10,000 for building fortifications on the Thames and Medway. The castles of Deal, Walmer, and Sandown had turf laid on their walls, but it is written of Sandwich that "the chief magistrates there kept to their old trade of disagreeing, and have left off fortifying themselves." Along the east coast too, the indefatigable Sir Bernard found scope for his energies, and at Harwich works were constructed by him, which repulsed the attack of the Dutch fleet in July, 1667. In the north, fortifications were either erected or repaired at Tynemouth, Scarborough, Bridlington Quay, and Hull. Doubtless at other places works were erected or strengthened at this juncture; but the foregoing are the principal that were executed up to the date of the peace which was concluded between England and her foreign enemies in the autumn of 1667.

Nothing further appears to have been undertaken in the construction of coast defences until the middle of the reign of Queen Anne, when an invasion of England was projected by the King of France on behalf of the Pretender. This project received both the pecuniary help and the prayers of the Pope; and great preparations were made for the extension of out fortifications, so far as the purchase of the necessary lands is concerned. Large quantities were taken under acts of Parliament at Portsmouth (for the Portsea Lines, &c.), at Harwich, and at Chatham; but with the exception of one fort at Portsmouth, I do not find that works were commenced at any of these places until nearly fifty years afterwards.

The next works of importance were constructed during the reign of George II.—viz., the lines at Chatham and Devonport, which were commenced towards the end of the reign of that monarch. An extension of the fortifications at Gosport, batteries on the Southsea shore, and a small work since replaced by Fort Cumberland, were erected at about the same time. Batteries were also ordered on sundry points in Milford Haven, and at several points along the south coast; the cause for all these preparations being, as cited in the preamble of the Act 31 Geo. II., cap. 39, "the unjust and hostile invasion made on His Majesty's dominions in America and the Mediterranean, and great preparations made in France for invading these realms."

Towards the middle of the reign of George III., when the Duke of Richmond was Master-General of the Ordnance and during the French Revolutionary War, still further additions were made to our coast defences. At Portsmouth, Portsea Lines were built, Fort Cumberland was entirely reconstructed, the old Hilsea Lines were thrown up, and the western defences were extended by the construction of Fort Moucktou; a few batteries were also erected for the defence of Stokes Bay. About this time, also, Sheerness Lines were constructed, and the works at Dover were largely added to. Numerous small earthworks were also built at this juncture at various parts of the English coast; but they were allowed to fall into decay after the wars. At Plymouth, large quantities of land were acquired at various parts in the vicinity of the town and dock for the erection of Devonport Lines; and amongst other works which were now constructed was the line of redoubts and barracks which occupy the position known as the Maker Heights. Pitt (who took a great interest personally in these questions) intended to have erected a citadel on Maker Heights; but he was defeated by a majority of one (the Speaker's casting vote) in a proposal for the further extension of our fortifications at Portsmouth and Plymouth. After this, for half a century, we acted like the magistrates of Sandwich, and "left off fortifying ourselves." Men indulged in dreams of universal peace which were, however, rudely dispelled by the great Crimean war. Now we come, to the efforts of the present generation, and never has there been a time when it has been so difficult to deal with questions of defence. The introduction of steam, of rifled guns, then of iron-clad ships, which rendered necessary the construction of artillery of enormous power; these are the conditions with which we have had to deal during the last few years, and it may be confidently asserted we are second to no other nation, if we are not superior to all, as regards the steps taken to meet present requirements, in every department of coast defence.

I will now proceed to consider the principles which should guide us in the defence of this country in the present day. Since the periods of which I have been speaking. the British empire has been greatly extended, and the demands upon our resources have become proportionably enlarged. For the general defence of so vast an empire, we must first of all and mainly depend upon our seagoing fleet. It is to the fleet we must look for our first line of defence against invasion of this country, to maintain our communications with our foreign possessions, and to protect our commerce and our interests generally both at home and abroad. But the bases on which our naval power must rest are the ports, dockyards, and arsenals, in which our fleets and squadrons are harboured, coaled, and refitted. Thus we have naval establishments at Portsmouth, Plymouth, Chatham, and Pembroke, at home; at Bermuda, Malta, Gibraltar, and several other places abroad. These places are the roots from which our naval power springs, and they require special protection against attacks that may be made upon them, during the absence of our fleet, either by hostile naval forces alone, or by combined naval and military expeditions. If our navy could be kept up in sufficient strength to meet the navies of other nations at all points were hostile fleets or cruisers might attack us, questions about attack upon these naval arsenals would be disposed of. Very little reflection and calculation, however, are necessary to show that the resources even of this country, whether in money or in seamen, would not admit of our maintaining such enormous naval means as would, of themselves, suffice to defend these sources of our naval strength, and at the same time to protect our commerce, or to prevent an enemy from either landing on our shores or attacking our widely scattered commercial ports, whether at home or abroad. Even if it were possible that a fleet sufficient to fulfil all these duties could be maintained, such an application of the resources of the nation would lead to an expenditure of public money far exceeding that which would suffice for the defence of the country with the aid of other means. The first cost of such a navy would be enormous, and would have to be repeated every twenty or thirty years, and the expense for maintenance would be great and continual. Further, if the several sections of our navy were employed for the protection of the arsenals whence they are maintained, we should be using the fleet to maintain the dockyards instead of the dockyards to maintain the fleet; and each of the sections of our navy thus scattered over the world would be liable to be overpowered by the concentrated forces of the enemy. Other defences besides the navy are, therefore, essential for these nurseries of the fleet.

First, to consider the means which should be applied for the defence of these places against naval attack. These are, big guns above water, and big mines below water, placed, of course, at the proper distance in advance of the object to be protected. Booms of timber, rafts, chains, or nets, might also be used for obstructing channels; but the attention that has been given during the last few years to the application of submarine mines has rendered these passive obstructions of minor importance.

To proceed then to consider active obstructions, or mines below water.—These are now, in most cases, necessary to obstruct the passage of ships, and to keep them under the fire of the guns above water, and have become of especial importance since iron armour has been applied to the sides of ships, and thus these vessels of war have become most vulnerable at their bottom. There are two classes of these mines—one, exploded by mechanical contrivances, the other exploded by electricity. Those exploded by mechanical means should be of a size to contain about 150lbs. of powder. They are much less costly than the others, and can be placed in position more expeditiously; could moreover be applied in any number, but they are inapplicable in positions where it is necessary to keep the channel open to friendly vessels. In such cases, electric torpedoes must be used. These admit of a friendly vessel passing over them in safety, and of a ship in chase being sunk by the completion of the electric circuit. Their charges would be about 1,000lbs., of gunpowder, or about 400lbs, of gun-cotton, and would ensure the destruction of a ship by their explosion, not merely when immediately over them, but even if any portion of her were within forty or fifty yards of the position.

It used to be the fashion, even amongst professional men, in this country, to consider this mode of defence as being incapable of practical application; but of late years a very different opinion has prevailed and the effective application of submarine mines, used in conjunction with forts and floating-batteries is of immense importance, not only in connection with fortifications, for the defence of our great naval stations, but also for our minor ports, and for the protection of all places on the seaboard. Foreseeing the important part that submarine mines would play in coast defences, I had the honour of proposing to Lord de Grey, in 1862, that a special committee should be appointed to consider and report upon the question of their application to defence of harbours. Lord de Grey at once recognized the importance of such an inquiry, and appointed a committee, which, after prolonged investigation and experiment, has made a most valuable and interesting report upon the subject, We are now in a position to apply this system of defence to any extent that may be required for the protection of our harbours and other points upon our coasts; and we are much indebted to the committee for the thoroughly practical results which we are now enabled to attain in this important and inexpensive element of national defence.

The question is sometimes asked,—Whether the applications of submarine mines will not render unnecessary the employment of forts and batteries, for defence against naval attack. Forts and batteries, however, are still required in all important cases to cover the torpedoes and prevent their being tampered with. It must also be remembered that whilst the submarine mine is harmless unless the ship comes near it, the shot from the battery can injure the ship whatever may be her position within effective range. Further, although probably our harbours might be efficiently obstructed by torpedoes in at from seven to fourteen days' notice, yet one condition is that the weather should be sufficiently favourable to allow them to be exactly laid. There are, again, certain positions where, even if the torpedoes are laid, they might be disturbed by a violent storm, and, possibly, an attack on the positions in which they were to serve might take place before they could be renewed; and though the periods of the year at which these difficulties might arise are short, yet the bare possibility of interference in the application of a complete torpedo system prevents our placing entire reliance on such a defence for the protection of places on which the warlike power of the nation, both for offence and defence, must in a great measure depend. Therefore, although submarine mines are a most important element in the defence of our harbours and coasts, and add greatly to the power of our forts to resist a naval attack, they must not be regarded as substitutes for permanent works of defence at our naval arsenals and harbours, and other important ports.

To proceed now to consider the employment of big guns above water. These with all the numerous accessories for their service must be placed in positions so protected and arranged as to give them a decided superiority over the artillery of assailing ships. The question then arises whether they shall be placed afloat in strongly protected vessels, *i.e.* in floating-batteries; or at fixed points either on land or on shoals, *i.e.* in forts. It is often said, "Why don't you protect your ports by floating-batteries alone?" The same reasons, however, as have been before adduced against the employment of our sea-going navy, prevent our employing special floating-batteries alone for this object. Such a system would necessitate our maintaining at each of our chief ports a naval squadron, sufficiently powerful to resist the attack of the superior force of the enemy. Then again arise the questions, "What is a sufficiently powerful force to maintain at each point for this object; what would be its first cost; in how many years will it be necessary to repeat the outlay for it: what will be the expence of its annual maintenance?" It is impossible to examine these questions without arriving at the conclusion that even if our resources in money and in seamen rendered it practicable to maintain such a force in addition to our sea-going navy, the defence of our ports can be effected much more efficiently and economically with the aid of other means. Irrespective, however of the question of the expense of providing for coast defence by floating-batteries alone, very little consideration is requisite to understand that if there be positions on land from whence an effective fire can be brought to bear on the channel, anchorage, or shore to be defended, there is no object in placing the guns in vessels afloat. In positions such as I have referred to, there cannot be any object in substituting an unsteady platform—on which the amount of protection that can be afforded is limited by considerations inherent to floating structures and which is liable to be taken away or to be sunk—for a fixed and perfectly steady platform on shore, which can be fully protected, either against its fire being silenced, or from capture by an enemy. In cases, however, where the distance between forts is so great that the intervening space cannot be properly commanded by their fire, or where it may be necessary to have advanced batteries of artillery at a distance from the shore, and where foundations for fixed works cannot be obtained without expense and difficulty disproportioned to the object, it becomes necessary to employ floating defences.

In short, we must, in each case, consider—1. Whether we can provide for the defence by forts without floating-batteries. 2. If not, to what extent floating defences should be applied in conjunction with forts. And 3. Whether the circumstances are such as to render it advisable to employ floating-batteries in substitution of forts. The question is not one, as it is often put, of "floating-batteries versus forts." There is no "versus" in the matter. Both are required in their proper places.

The question of the kind of floating-battery to be employed for harbour defence has from time to time been much discussed. Ten years ago, at my suggestion, a committee was appointed by General Peel to consider the subject. Admiral Cooper Key, Colonel Wilmot, R.A., and myself were the members of this committee. We then recommended the employment for harbour defence of small vessels, each carrying a fixed iron tower for four guns, and provided with eight ports. It is curious how nearly this vessel approached the 'Monitor' type first used in the memorable fight at the mouth of the James river, in America, with the 'Merrimac,' in 1862. I believe it is generally admitted that the 'Monitor' class of vessel is the best kind of armour-clad floating-battery for coast defence; but amidst the many projects for floating structures for defence now advocated, it would be presumptuous for me to give any decided opinion on this subject. In some cases iron-clad 'Monitors,' supplemented by a mosquito squadron of gun-boats, might be employed, and, to oppose unarmoured cruisers or privateers to the attacks of which alone the less important harbours would be liable, small gun-boats of light draught in conjunction with submarine mines would alone suffice. I take this opportunity of showing a model of a small gun-boat for one gun, proposed by Mr. Rendel, of the Elswick Ordnance Company, in consultation with Admiral Cooper Key, which appears admirably well adapted for the small class of vessels for harbour defence.

I now pass on to consider the defence of our great naval arsenals, in the event of an enemy obtaining a footing on our shores. We maintain a large military force of regulars, reserves, militia, and volunteers, and thereby admit the possibility of a campaign taking place in this country. The landing of a hostile army on our coasts must be admitted to be a difficult operation; but it would, to say the least, be very unwise if we were to conclude that invasion is impossible because it is difficult. It must be assumed that the main object of an enemy in an invasion would be to get to London; for by doing so he would not only occupy the commercial heart of the empire and the seat of government, but the main military arsenal of the empire at Woolwich would also fall into his hands. Supposing him to have obtained a footing on shore, and to be advancing on London, we interpose between him and his object the regular army, in conjunction with the armed and organized manhood of the country, more or less disciplined, and aided by such temporary defences as could be thrown up at the time of expected attack. But as the best disciplined and the greater part of our military forces must be employed to cover the capital, we must arrange our plan of defence so that as few disciplined troops as possible may be necessary for the defence of other points in the country which must be defended, but which cannot be covered by the operations of the main army. Portsmouth and Plymouth, for instance, are therefore defended on the land side by the aid of fortifications which will enable a comparatively small number of partially disciplined forces, with the aid of a few regular troops, to protect those places against capture or bombardment, whilst the main army would be employed in the defence of London and Woolwich. A mistake is commonly made that because the places I refer to are fortified, the garrisons of those places must be largely increased. The case is precisely the reverse. Even if all the outer line of forts to landward at either Portsmouth or Plymouth were fully manned at the same time (which would be quite unnecessary, not more than one-half need be fully manned at the same time), only between 6,000 and 7,000 men would be required for the purpose at each place respectively, and only a very small portion of these need be regular troops. The remainder of the garrisons would consist of a movable force, which in any case we must have for the defence of these places, but which in the absence of the forts must be of sufficient strength and sufficiently disciplined to meet the enemy in the open field, whilst with the forts it may be comparatively small in number, and only disciplined to take up a fighting position, under the support of the works, as that part of the fortified line assailed. Unfortified, an enemy would only have to detach about 15,000 or 20,000 men from the main invading army to effect in a few days the destruction of all our ships and naval establishments at Portsmouth; fortified, he must employ an army of at least three times that number, and must have a considerable time at his disposal to undertake a regular siege. Unfortified, no force that, in the case referred to, we could afford for the garrisons of these places could protect either against the attack of 15,000 regular troops; fortified, there is no difficulty in providing the numbers and description of troops that would be capable of making a good defence of these nurseries of the navy. Unfortified they at once fall if an enemy were to obtain a decisive victory over the army in the field; fortified, they remain in our hands even under such untoward circumstances, and thus enable us to avert the destruction of our naval power at a period when all the resources of the country will be required to enable us to retrieve the position temporarily lost.

A few words in conclusion. We are often told that these works are unproductive, and so in one sense they are; but who shall say what effect permanent measures of defence may have upon the position of this nation? I verily believe they tend to peace and to the development of the prosperity of England. But we are met with other objections. It is commonly said that there is no use in constructing permanent fortifications, because the inventions of one age render useless the efforts of the previous generation. History, however, does not support this statement. At this moment we are turning to account, and with good effect, works erected by Henry VIII. more than three centuries ago. In like manner, works constructed in the time of Charles II. and in the reigns of George II. and George III. form parts of the system of fortifications we are adopting at the present day. Then we are told that these measures are so extravagant. The fact, however, is that, by the aid of fortifications we are enabled to defend the empire with fewer troops and a smaller navy than would otherwise be necessary, and that they thus tend greatly to economy. If we are to make provision for defence at all, it is only by the aid of fortifications that we can have an economical system of defence. They say then, that our fortifications "lock up" troops. I have shown you that, on the contrary, they enable us to utilize our auxiliary forces and to set the regular army free. But again, we are told that we ought to depend upon our navy; but the main purpose of the fortifications is to enable the navy to do its duty effectively. The navy is without doubt the arm on which we must mainly depend; but that is no reason why we should tie it down to our side! Lastly, they say, "An enemy won't go near these fortifications." My reply is, that that is the very object for which they are provided. To sum up. The truth is, that to provide an efficient system of defence at the least cost to the state, the sailor, the soldier, and the military engineer must each occupy his proper place. The navy and the army are the vital principle of defence; and fortified arsenals and harbours are the centres of refuge and action for both. Take away fortifications, and you are unable to turn your auxiliary forces to proper account; you leave an army insufficient for the duties it has to perform; a navy, scattered, unsupported, and with no protected home.

## ON THE SUBMERSION AND RECOVERY OF SUBMARINE CABLES.

By H. C. Fleeming Jenkin, Esq. F.R.S., Professor of Engineering in the University of Edinburgh.

The speaker began by stating that his object was to explain the principles on which engineers had acted in laying and recovering submarine cables, rather than to exhibit the details of the machinery employed. The general construction of electrical cables was first described and specimens were shown; especial attention being drawn to the deep-sea French Atlantic cable, consisting of the following parts:—A copper conductor, gutta-percha insulator, and jute serving, surrounded by ten wires of homogeneous iron, each served with five Manilla yarns saturated with tar.

Table I.—Construction of French Atlantic Cable—*Deep-Sea Section.*

| | Lbs. Weight per Knot. | Diameter in Inches. | Breaking Strain. Lbs. |
|---|---|---|---|
| Copper | 400 | ·168 | 644 |
| Gutta-percha | 400 | ·463 | — |
| Serving | 234 | ·669 | — |
| Homo. wires (10) | 1589 | ·100 | 950 |
| Manilla strands (50) | 1091 | — | 550 |
| Each served wire | 268 | ·245 | 1,550 |
| Cable | 3701 | 1·134 | 16,530 |

Weight of cable in air ... 1·652 tons per knot.
" in water 0·753 "
Strength in tons ... ... $7\frac{3}{8}$ tons.

Table No. 1 gives the dimensions, weights, and strengths of each of the component parts. The wire served with hemp will bear a greater weight than the sum of the weights borne separately by the wire and the strands; and, again, the served wires, when formed into a rope, bear a greater weight than the sum of the weights which each will bear. Moreover, while the homogeneous iron elongates less than one per cent. before breaking and the hemp elongates only 0·75 per cent., the two combined stretch three per cent. This paradoxical result is due to want of absolute uniformity in the strength of each part; when separate, each breaks at the weakest point; when combined, the weakest points seldom coincide; hence the strength of the combination is the sum of the minimum strengths. The so-called spiral or helical form does not really render the cable elastic or liable to stretch, nor does it compress the core inside the sheathing, as was shown by an experiment where the core was actually withdrawn without causing the collapse of the sheathing. The manner of coiling the cable on board ship was explained by diagrams and models; it being shown that in order to avoid putting a twist into the rope when taking it out of the hold, it was necessary to put a twist in when coiling it away. Bad coiling produces kinks or loops drawn tight, which are avoided by a cone filling the eye of the coil, and by rings or equivalent arrangements preventing the bight as drawn out of the hold from lashing out under the influence of centrifugal force. The following table gives the dimensions and contents of the Great Eastern tanks as arranged for the Atlantic expedition. These tanks keep the cable under water on board ship to facilitate the electrical tests. They carry a weight of 5,000 tons, in a hulk of 180,000 cubic feet, the tanks not being filled quite to the top.

Table II.

| | Diameter. | Depth. | Cable knots. |
|---|---|---|---|
| Fore tank | 51ft. 6in. | 20ft. 6in. | 728 |
| Main tank | 75ft. 0in. | 16ft. 6in. | 1100 |
| After tank | 58ft. 0in. | 26ft. 6in. | 912 |

Notwithstanding their enormous weight and size, these tanks occupy a very insignificant proportion of the whole bulk of the Great Eastern. Mr. C. W. Siemens has for light cables employed a sort of reel or drum on a turn-table with partial success, instead of the fixed tank and coil. From the tank the cable when paid out passes over a pulley and along a trough to the break drum, the object of which is to restrain the free exit of the cable to such an extent as is desired. The cable is laid hold of by being passed several times round a drum, as a rope making fast a vessel may be seen to be passed round a bollard; the friction allows a slight strain at one end to prevent a very heavy pull at the other end from causing the rope to slip round the drum The slight pull at what may be called the light end of the rope is given by a series of jockey pulleys which play the part of the hand when the rope is allowed to slip round a bollard, but in paying out a cable the rope does not slip round the drum; the drum itself turns round restrained by a friction band or belt. It is essential that this restaining friction should be constant; a result attained by the Appold Break, which was explained by models and diagrams. In this arrangement both ends of the break strap are attached to one lever in such a manner that when the drum begins to turn it tends to lift the lever and weight hanging to it, and as the lever is lifted it slackens the break strap, until the difference of tension on the two ends of the strap is equal to the weight hanging on the lever. When this is the case, the lever is no longer lifted, but remains stationary with the strap, allowing the drum to turn, restrained by a constant friction equal to the weight on the lever. If the coefficient of friction increases, the lever will be a little more lifted and the strap slackened; if the coefficient of friction diminishes, the lever and weight will fall, tighteuing the straps; but in any case the retarding force will be simply equal to the weight. From the break drum the rope dips under a weighted pulley, which rides as it were suspended on a V of taut cable; if the strain increases, the rope straightens, and raises the pulley; if the strain diminishes, the weight and pulley fall; thus the height of the pulley indicates the strain. This instrument is called the dynamometer. Lastly, the rope passes over a pulley into the sea. Having shown how the cable was treated, the speaker proceeded to show how the strains to be expected could be calculated. A cable paid out in air hangs in a catenarian curve, but in water lies in a straight line, and the strains in the two cases are wholly different. In air the rope meets with no sensible obstacle to its motion either longitudinally or in a direction perpendicular to its own length; in water, on the contrary, each foot of a cable meets with an opposition to its motion perpendicular to its length, which we may call q, and for the Atlantic cable

$$q = 0{\cdot}154\ v^2,$$

where $v$ is the velocity of the cable normally to its own length in feet per second.

Thus, as the cable weighs 0·2575lb, per foot, it cannot sink faster than the speed given by the equation

$$0{\cdot}2575 = 0{\cdot}154\, v_1^2,$$

form which $v^1$, the settling velocity, is found to be 1.294ft. per second, or 0.765 knot per hour. The result of this resistance to displacement is that the cable lies in a straight line, not in a catenary curve, supported as it were by an inclined plane of water constantly yielding at the velocity $v_1$. The inclination of the straight line depends on the velocity of the ship and on $v_1$ not being at all affected by the tension of the rope. The angle $\phi$ at which the cable will lie may be calculated as follows. Let P be the resistance of the water to displacement by each foot of the cable of the weight $\omega$ when lying at the angle $\phi$,

$$P = \omega \cos. \Phi;$$

let $v_{11}$ be the velocity at which the cable moves perpendicularly to itself,

$$v_1 = v \ \sin. \varphi,$$

where $v$ is the velocity of the ship

$$\text{Also } P = \omega \frac{v_{11}^2}{v_1^2};$$

$$\text{hence } \cos. \phi = \frac{v_{11}^2}{v_1^2} = \frac{v^2 \sin.^2 \phi}{v_1^2},$$

$$\text{and } v_1 = \frac{v \sin. \phi}{\sqrt{\cos. \phi}}, \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 1^\circ$$

and assuming the the resistance is proportional to the square of the velocity, we have $\omega = q v_1^2$, and hence $\frac{\omega}{q} = \frac{v^2 \sin.^2 \phi}{\cos. \phi}$, or

$$\frac{\omega}{q v^2} = \frac{\cos. \phi}{\sin.^2 \phi}, \text{ from which we have}$$

$$\cos. \phi = \frac{\sqrt{\omega^2 + 4 m_2} \quad - \omega}{2m} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 2^\circ$$

where $m = q v^2$.

From this formula, as indeed from common sense, it appears that the greater the value of q and of $v$, the smaller the inclination with the horizon. The rough Atlantic cable, when the ship was going at the speed of six knots per hour, lay at an angle of 6¾°, so that the inclined plane was seventeen miles long, and each foot of the cable took nearly three hours to reach the bottom. The strain T at the top of the inclined plane, if there were no friction preventing the rope from slipping back along the plane, would be equal to the weight of a piece of cable hanging plumb from the surface of the water to the bottom, or

$$T = \omega x,$$

where $\omega$ is the weight per foot run of the cable and $x$ is the depth in feet. But there is sensible friction which helps to relieve the strain precisely as when a chain is lying on a solid inclined plane; calling $m_1$ the coefficient of friction in lbs. per foot length of cable at the velocity $v$ in feet per second, and assuming that $m_1 = q_1 v^2$, the experiment of the Atlantic cable showed that $q_1 = {\cdot}00504$ (this is equivalent 0·81 cwt. per knot of cable when slack is paid out at the rate of one knot per hour.) The result is, that when slack is paid out, say at the rate of 1 knot per hour, and when $\phi = 6{\cdot}45^\circ$, the strain is diminished by one-half, and if slack were paid out at the rate of 1·4 knot per hour, or 23½ per cent., this particular cable would require no retarding force whatever. The strain $T_1$, when the velocity of the cable is $v_{111}$, can be found from the following formula:

$$T_1 = \omega x - m_1 \frac{\left(\frac{v_{111}}{v} - \cos. \phi\right)^2}{\sin. \phi} x \ \ldots\ldots\ldots\ldots\ldots\ldots \quad 3^\circ$$

Cables of light specific gravity have a small settling velocity and lie at great length in the water, and if they are also rough, the coefficient $q_1$ may easily be so great as to relieve the break of most of the strain which would be necessary to lay a cable of equal weight but small bulk and smoother surface, with the same amount of slack. If no slack were laid there would be little difference between the tension required for cables of different construction but of equal weights in water. When much slack is laid, all cables will be considerably less strained than if laid without slack; and finally, the faster the ship goes the less slack is required to produce any given amount of relief.

The correctness of the above theory has been amply proved in practice. If in seas 2 miles deep the cable hung in a catenary 12¾ miles long, the weight to be carried would be 8½ tons, and the strain on the cable 29 tons; while if the cable hung in a catenary the inclination of which to the horizon at the stern was 9° 30′, the length would be 24 miles, the weight 17 tons, and the strain 102 tons instead of about 14 cwt.—the strain actually observed for the Atlantic cable when being paid out at 7 knots per hour while the ship was going at 6 knots per hour. The rise and fall of the ship, even in heavy weather, very slightly affects the strain while paying out, on account of the slight inclination of the cable to the horizon. The margin of strength in deep-sea cables of the Atlantic type is even greater than is given in most engineering works, since the cable will bear tenfold the strain which is found necessary in laying. The process of grappling was next described, and the operation illustrated by dragging a miniature grapnel over the floor, so as to hook a chain lying there. When the cable is hooked, the strains on the grapnel rope are simply the weights of the bight lifted, and the length of this bight depends on the slack. Thus with 14 per cent. of slack the length of the cable lifted will be 4·89 times the depth to which it is raised. Thus in 2 miles of water about 9·8 miles of cable will be lifted, the weight on the grapnel will be 6·86 tons, but the strain on the cable will be only one component of this weight resolved in the direction of the tangent to the curve at the grapnel; this strain will be 5·5 tons. Thus it is clear that in calm, weather, with 14 per cent. slack, the cable can be lifted from a depth of two miles. This was actually done upon one occasion; but owing to pitching of the ship the cable parted, and was successfully recovered by the obvious device of grappling the cable in two points about 2½ knots apart, and breaking the cable at the point furthest from land; the loose end then hung down over the other grapnel, and it is obvious that by this plan the strain on any cable in any depth can be limited to the simple weight of a length of cable hanging from the surface to the bottom. The Atlantic cables will bear five times the strain due in this manner to 2 miles of depth, and for this operation the margin of strength is also ample. The cable is hauled in by machinery very similar to that adopted for paying out; the drum being simply turned in the opposite direction by a steam engine, if only a small length is to be picked up. If many miles are required, the cable is transferred to the bow, and hauled up by a double drum to avoid the fleeting necessary on a single drum. The friction of the water during this operation adds to the strain: thus with the value of $q_1$ previously found, at 1 mile per hour the friction per mile would be 0·81 cwt., adding in a depth of 2 miles 1·61 cwt. to the strain due to the simple weight; besides this there is some resistance due to the displacement of the water by the bight of the rope at the bottom, and some, extra weight due to the fact that the cable hangs in a catenary, not in a straight line. The length of this catenary depends on the rate at which the cable is hauled through the water; but even after allowing for all these things, the strength of the cable is from three to four times greater than the strain which in fair weather need come on the cable when being picked up from a depth of 2 miles; a margin of strength not unfrequently adopted even in permanent engineering works. It was by calculations like these that before the 1865 cable had been recovered in 1866, the speaker was able to write in the *Times* of August, 1865, "If the cable retain its strength, as it probably will, it can certainly be raised;" and now that experience has confirmed theory, engineers are justified in looking forward with great confidence to the continued prosperity and extension of deep-sea telegraphy. The following tables give some further information as to the French Atlantic cable about to be laid, which will cover 50 acres of ground, being a narrow strip, 3,534 knots long, and a little more than an inch wide.

TABLE III.—LENGTHS AND WEIGHTS OF MATERIALS USED IN FRENCH ATLANTIC CABLE.

| | Knots. | Tons. |
|---|---|---|
| Copper wire ... ... ... ... | 24,948 ... ... ... | 533 |
| Gutta-percha ... ... ... ... | 3,564 ... ... ... | 549 |
| Jute serving ... ... ... ... | — ... ... ... | 500 |
| Homo. wire ... ... ... ... | 27,222 ... ... ... | 1872 |
| Iron wire ... ... ... ... ... | 9,941 ... ... ... | 2855 |
| Total iron and homo. wires ... | 37,163 ... ... ... | 4727 |
| Manilla strands ... ... ... | 136,110 ... ... ... | 1286 |
| Clark's compound ... ... ... | 881 ... ... ... | 652 |
| Deep-sea cable ... ... ... | 2,643 ... ... ... | 4366 |
| Shallow-water cable ... ... | 921 ... ... ... | 3881 |
| Total cable ... ... ... ... | 3,564 ... ... ... | 8247 |

TABLE IV.—LENGTHS OF EXISTING CABLES.

| | Knots. |
|---|---|
| Atlantic (two) ... ... ... ... ... ... ... ... | 3748 |
| Malta, Alexandria (two) ... ... ... ... ... ... | 2254 |
| Persian Gulf ... ... ... ... ... ... ... ... ... | 1308 |
| Home seas ... ... ... ... ... ... ... ... ... | 1277 |
| Miscellaneous (approximate) ... ... ... ... ... | 1350 |
| Total ... ... ... | 9937 |

## THE COAL-MINES OF SCOTLAND.

Mr. Ralph Moore, in his report of the mines and collieries in the eastern district of Scotland, for the year ended 31st December 1868, shows that there were, in and about coal-mines there, 43 lives lost. The number of male persons employed was 29,000. The number of women working on the surface, 683; the quantity of coal raised, 8,456,084 tons; and the quantity of coal raised for every life lost, 196,653 tons. In inspected iron-stone mines one life was lost. The loss of life last year was less than in 1867, and the quantity of coal for every life lost was above the average. Falls of roof and coal are still the most frequent cause of death. There were boiler explosions last year—one at Bo'ness and the other at Motherwell. Both were high-pressure boilers, 5ft. diameter, ⅜-in. plates. The former had been twenty years and the latter fifteen years in use. It did not appear that either of them had been short of water, and, excepting the worn-out conditions of the boilers, there was nothing to account for the explosions. A question arose out of the Bo'ness explosion as to compliance with the 13th general rule, which requires that every boiler shall be provided with a proper steam gauge. At the suggestion of the Crown counsel, I sent a circular to the coalmasters in my district, requesting them to put a steam gauge on each boiler. Many of them have already complied, and others are doing so. The shaft accidents are still high, and are doubtless in part owing to the increased number of shafts necessary for compliance with the statute. I have taken every opportunity of examining such boys as came under my notice as to the educational provisions of the statute. The practice appears to me not to allow any boy to enter the pit until he is twelve years of age. I have found boys under that age, but they could generally read and write, and I believe there are not many young boys who go down the pits in this district without being able to read and write a little. In scarcely an instance did the boys attend a night school. As a general rule, boys get all the education they are likely to get before they enter the pit. There can be no doubt it would inflict a hardship on many a man struggling to bring up a large family to compel him to dispense with the services of his boy until twelve years of age, but there can be as little doubt as to the benefit to the boy. Education at the colliery villages is both cheap and plentiful. There are plenty of good schools, with good teachers, convenient to the villages where the parents reside. Last year, there were 147 companies working coal in the district, some of them raising more than 400,000 tons of coal annually, and some of them less than 5,000 tons. As the result of a careful estimate, I find that of the persons employed, every fifteenth person is employed in looking to the safety of the others in the shape of manager, overman, deputy-overman, fireman, and overlooker. There are, therefore, in this district 2,000 persons employed by those companies to keep the pits safe for 29,684 persons engaged in and about mines in working and conveying coal from the face until it is put into waggons at the surface. Where the safety of the persons employed does not depend upon themselves, it depends upon these 2,000 persons, and the degree of safety which they afford depends upon the discipline and control exercised by the owners and principal agents, who alone have the control of this large staff. No important alteration can be made unless they sanction it. They propose the special rules, and can make application for their amendment at any time; and it is in their power, either by their own observation, or by employing other skilled persons to do it for them, to see that the special rules are observed, and that proper discipline is maintained by the regular staff. The opening up of new pits has kept up the demand for miners, and, as a natural consequence, wages have not been reduced.

Mr. Alexander's report upon the mines and collieries in the West of Scotland contains the following:—For the past year, the number of collieries in operation has been 203; the persons employed in and about them were 21,160; and I estimate the total produce of coal and dross at 6,253,875 tons. The fatal accidents connected with these works were forty, causing the loss of a like number of lives. Of these, eighteen were married men, whose untimely death left eighteen widows and twenty-eight fatherless children unprovided for; fifteen were single or unmarried, and seven were boys. Though the number of fatal accidents for the past year has been slightly in excess of 1867, it is still under the general average, and compares with former years favourably. The loss of lives from explosions of fire-damp were four, and of these at least three happened through recklessness and neglect. The quantity of gas causing the accident in each case was trifling, and, with one exception, the sufferers survived their injuries for some days after. More stringent observance of the special rules would prevent the recurrence of all such distressing events. One of the most important precautions in connection with this branch of mine management is to carry out a systematic examination of the working places every morning before the workmen are allowed to enter them. I find that the best way to do this is to provide that the engineman shall not allow the descent of workmen into the colliery on any morning till after the fireman has made his underground examination, and has signalled to the surface to that effect. With this precaution, however, there is still the difficulty of proving or knowing that the fireman has faithfully performed his duty. It would narrow the likelihood of such an omission, and form a satisfactory check, if an additional rule was introduced compelling the fireman of each wing to leave his mark or the date of examination with chalk on the face of the coal in every working-place. The accidents from falls of coal and roof were exactly 50 per cent. of the whole, or rather under the average of bygone years, and, with two exceptions, they happened to the sufferers while working at the coal face, or while engaged taking down part of the roof and securing it. In shafts the accidents are also under the average of former years. Three fell away from the cage or kettle on which they were being lowered or raised, two fell from the surface, one was thrown off a scaffold while making repairs in the shaft, and another by mistake pushed a hutch into the wrong division of the shaft, and fell to the bottom with it. It is discouraging year after year to have to call attention to loss of life in the way last described; and if the general rule were introduced enforcing the use of self-acting guards or wickets at all pits where coals are put out, this description of accident would forthwith cease to be heard of. The fatal accidents of a miscellaneous character and above ground have been much in excess of the average of past years. In ironstone mines and the coal measures, worked in connection with coal or with any disused or exhausted coal-mine, the fatal accidents were four. Of these, two were occasioned by falls of roof, one by the breakage of a crane rope, and one by a stroke from his punch or lever, which slipped while he was using it to force off a piece of ironstone at the face of his place. The accidents of a non-fatal kind which have been reported from every description of mine were 237; explosions of fire-damp, 80; falls of coal, ironstone, and roof, 112; in shafts, 16; and from miscellaneous causes and above ground, 29. Improvement in the working details of the collieries generally, though not accompanied by a marked diminution of loss of life, is gradually advancing, and the mines of 1868 are unquestionably superior in point of management and skilful appliances to those of twenty years ago. The standard of good management is not strictly speaking, to be measured by the amount of loss of life; for it is a well-known fact, that the greatest number of accidents do not always happen in the worst-managed mines. There is something connected with underground labour incompatible with safety; and we have it from undoubted statistics that a certain number of lives will be lost annually, ranging from five to ten, for every million tons of coal raised. What the real amount of risk is, independent of recklessness on the part of the sufferers, or neglect on the part of management, will probably vary in different mineral fields; but I believe that it will be a long time before the fatalities in the mines of this country will average fewer than five or six for every million tons of coal raised, and in the most favourable situations, and with the greatest care not less than four. There is another point of view, however, and perhaps a more cheering one, from which to measure the progress of improvements as affecting life, and that is to consider whether the average age which persons continue to labour in mines, has not been extended. I cannot adduce evidence of a satisfactory kind but I am of opinion that it has been lengthened from a sixth to a seventh. The fatal accidents which took place in 1868 happened to persons while labouring in and about mines, whose ages averaged sixty-four, and ranged from sixty to sixty-nine years.

## ON THE SUBSTITUTION OF SODIUM FOR PHOSPHORUS IN LUCIFER MATCHES.

Dr. H. Fleck, of Dresden, has instituted a series of experiments with the view to obtain a non-poisonous paste for application to lucifer matches. He ascertained, by some preliminary experiments, that sodium, when minutely divided along with explosive substances, becomes highly inflammable when simply moistened with water. A mixture, constituted according to the formula—

$$(KO,NO_5) + Na + 2C = (KO,CO_2 + NaO,CG_2) + N,$$

formed a grayish-coloured mass, which, on being touched with a moistened glass rod, ignited like gunpowder; this mixture was, however, found to be unfit to ignite ordinary brimstone matches, or a cotton wick soaked in petroleum. In order to mend this defect, black sulphuret of antimony was substituted for the charcoal, according to the formula—

$$3(KO,NO_5) + Na + (SbS_3) = (NaO,SbO_5) + 3(KO,SO_3) + 3N,$$

and the mixture made up of—

| | | | |
|---|---|---|---|
| 0·5 | grammes of sodium | = 4·65 | per cent. |
| 66·0 | " nitrate of potash | =61·39 | " |
| 36·5 | " sulphide of antimony | =33·96 | " |

Provided that during its manufacture this mixture is kept thoroughly dry, it has been found to answer admirably well. The mode of making it up is briefly as follows:—Pure solid paraffine is put into a well-stopped glass flask, and melted over a sand bath; when fluid, clean pieces of sodium are added, and liquefied under the paraffine. As soon as the metal is thoroughly liquefied, the flask is closed and shaken for about ten minutes, which has the effect of granulating the metal, or rather reducing it to a fine powder. The metal is then poured out of the flask along with the paraffine, and the sodium taken out of the paraffine by means of a clean dry spoon; from 30 to 35 per cent. of paraffine remains adhering to the metal; this, however, does not impair its inflammability, while it tends to preserve the metal.

Owing to this increase, instead of 5 grammes, 6.6 grammes of the metallic powder thus obtained must be weighed off. The incorporation with the other ingredients previously well dried and warm, is effected under petroleum in metallic mortars, but each of the substances is first mixed with some petroleum, and pulverized separately before being triturated with the sodium; instead of gum or glue, caoutchouc, previously soaked in light petroleum oil at 110 deg. C. for ten or twelve hours, is used as mass to form an adhesive paste with the other materials. According to several accounts from Germany, this plan of substituting sodium for phosphorus has been favourably taken up by some of the largest and leading manufacturers of lucifer and fusee matches. There is said to be not the least danger in the transport.—*Dutsche Industrie Zeitung.*

## REVIEWS AND NOTICES OF NEW BOOKS.

### *The Handbook of Iron Shipbuilding.* By Thomas Smith, M.I.N.A. London: E. and F. N. Spon.

It is, unfortunately, seldom that we find men eminent in their profession willing to benefit the public by their knowledge which has been acquired during many years of varied experience. It is, indeed, too generally the fact that such knowledge is jealously guarded by them, and the only method by which anyone can acquire it, is to undergo similar training, and, by picking up a "wrinkle" every now and then, gradually to become proficient. In this case, however, the author, with a generous independence that cannot be too highly praised, and which evidently arises out of a certain consciousness of superiority in his profession, has given to the public a large amount of exceedingly useful information which has hitherto been most religiously kept secret. Although this work is but small, it appears to teach everything requisite for building an iron vessel; not only giving dimensions and a full textual explanation of every part of a ship, from the keel to the framing of the hatches, but illustrating such of these explanations as may require it by simple drawings that it is impossible to misunderstand.

In the second part of the work, besides tables of weights and results of experiments upon the strength of ships' beams; a vast amount of information is given as to the cost of vessels of various sizes, both as regards material and wages, every detail, even to the fitting up berths, being priced separately. The author has forseen an objection that might be urged against the usefulness of giving prices—viz., that the price of labour varies considerably in different districts—by giving examples of the cost of labour on an iron vessel, not only in London, but also on the East coast, at Liverpool and on the Clyde; thus making this portion of the work equally useful for all parts of the country. From what we have said, it will be seen that we esteem this book very highly, and consequently we strongly recommend it to all shipowners, shipbuilders, inspectors, shipmasters, foremen, and all who wish to know how a ship ought to be built or what it ought to cost.

### *Modern Practice of the Electric Telegraph.* By Frank L. Pope. New York. Russell Bros.

This is a good practical work on telegraph practice, chiefly with reference to the Morse system, which is almost universally adopted in America. It describes, by the aid of a great many excellent engravings, the various apparatus in use, and the principle upon which they act; also the methods of testing for disconnections, leakages, &c., and the various instruments employed for those purposes. There is also a chapter on telegraph construction, the hints contained therein, so far as regards land lines, being of a thoroughly practical and useful character. The chapter for learners contains a very simple set of instructions as to how to transmit messages by the Morse alphabet, and where that system is in force, will doubtless be found exceedingly valuable.

### *Bibliothèque des Professions Industrielles et Agricoles.* Edited by Eugene Lacroix. Paris: 54, Rue des Saintes-Pères.

This latest scientific publication of M. Eugene Lacroix—the indefatigable editor of the *Annales du Genie Civil* and the *Etudes sur l'Exposition*—is calculated to considerably enhance, not only his own already well-earned reputation, but also those of the able contributors by whom he has been assisted. Although the last-mentioned work (*Etudes sur l'Exposition*) is not quite finished, there being one more volume and the index unpublished, M. Lacroix has already published several volumes of a new work, entitled *Bibliothèque des Professions Industrielles et Agricoles*, which appears to embrace a large field of subjects. Thus the *Théorie Mécanique de la Chaleur*, which is translated from the German of Professor Clausius into French by Dr. Folie, is a very elaborate and complete treatise upon this difficult subject, but one which is most important to engineers and all interested in the economy of fuel. The second part of this treatise relates to the relation of the mechanical theory of heat to electricity. The next volume is upon a different subject, being an *Essai sur l'administration des enterprises industrielles et commerciales*, by M. Lincol, and will be found of great assistance to capitalists and managers of commercial enterprises of every description. A chapter entitled "Du rapport entre entrepreneurs et employés," in which the rights and obligations of employers and employed is considered, is well worthy the attentive perusal of both classes there indicated.

Another excellent little treatise, entitled "Armes et poudre de chasse," by M. Louis Roux, who is both an engineer and an enthusiastic sportsman, will be found useful to those who wish to understand the difference between the various descriptions of guns and gunpowder. The last volume of this series, or, rather, the latest that has as yet been published, "Carnet de l'ingéneur," is somewhat similar to the various engineers' pocket-books published in this country, and the fact of it having attained to its 14th edition is a sufficient proof of its value.

### *The Ruthven Hydraulic Propeller* versus *the Screw and Paddle.* London: J. Haddon & Co.

This pamphlet, which the author has been too modest to own, proceeds from the "Ruthven Hydraulic Propeller office," and, as might be expected, is devoted to the task of proving that the Ruthven propeller is the best method of propulsion in existence. In order to accomplish this feat, it has to be demonstrated that the Admiralty experiments with the hydraulic-propelled *Waterwitch* and the screw vessels *Viper* and *Vixen* were erroneous. This is done by asserting that in the *Waterwitch*, at the time of the trials. there was an enormous leakage of steam, although Mr. Murray could not discover it. Considering the eminence of Mr. Murray in his profession, and also that the engines were one of Messrs. Dudgeon's best jobs, it requires a considerable amount of credulity to accept the assertions contained in this pamphlet.

### *The Smoke Nuisance and its Remedy by means of Water; with remarks on Liquid Fuel.* By C. J. Richardson, Architect, &c. London: Atchley and Co., 106, Great Russell-street, W.C.

"If we look out on a fine summer's day through the louvre boards at the top of the Crystal Palace for a view of the great metropolis, we naturally exclaim, 'I see it—there is the smoke.'" is the remark of a clever writer. The object of this pamphlet is to change this natural remark into an absurdity, by showing how the smoke from domestic chimneys, as well as manufactories, may be altogether prevented. This, the author proposes to accomplish by so arranging the flue that water through a fine rose may play upon the smoke before it passes out into the air. No doubt by this means the solid particles in the smoke would be arrested, but we fear the expense would be too great to ensure its general adoption. The author, by means of a number of drawings, shows various methods of accomplishing his object, and contends that in this moist climate the rain would supply sufficient water. This, however we consider very doubtful, but would recommend our readers to peruse the work, as there are many very useful suggestions contained in it.

### *State Emigration.* An Essay. By Edward Jenkins, Barrister-at-law. 2nd Edition. London: National Emigration Aid Society, 16, Northumberland-street, W.C.

The consideration of this subject has within the last few years been forced upon all classes in Great Britain from the excessive depression in the labour market caused by the stagnation in trade. The author, having had experience in the colonies as well as at home, speaks with authority, and points out very forcibly the advantages of emigration, not only to those who are suffering from want of employment, but collaterally to the Government itself, and thus induces an argument in favour of an Imperial loan. So far as regards the advantages of emigration, we can from experience thoroughly agree with him. It is well known that the vast majority of intending emigrants are exceedingly helpless, both as regards the necessary funds as also in making proper arrangements for the journey and for their proper reception upon arrival in the colonies—or, in other words, of taking care of themselves. The National Emigration Aid Society has for its object the alleviation of both these difficulties, and we cordially invite our readers to assist them in carrying out such laudable purposes.

The Suez Canal.—The arrangements for opening of the Suez Canal on Nov. 17th are fully developed. The Viceroy of Egypt proposes to entertain his guests with unprecedented magnificence. On the banks of the canal are to be erected lodges, constructed, fitted, and decorated, so as to be reproductive of the characteristics of the several countries to which the guests belong. Public amusements, theatres, circuses, balls, and fêtes are to be provided for the recreation of the assemblage, which promises to be as brilliant as varied in its character. It is confidentally expected that the Empress of the French will attend in person; if this be the case the Emperor Francis Joseph of Austria will be present. The heir presumptive of the Italian Crown will represent King Victor Emanuel; the King of Prussia will send a member of the Royal family; and the Prince of Wales, possibly accompanied by Prince Arthur will represent Queen Victoria. The event is, therefore, likely to be one of extraordinary grandeur, and will doubtless pass off with great *éclat*. Its international significance will warrant these manifestations of this world-wide interest.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

A novelty in Fire Lighters has been made the subject of a recent patent by Mr. James Templeman, a manufacturer of these articles in Glasgow and London, which is also applicable as a fire reviver and temporary heater for cooking and other purposes. The main features of the invention consist in compressing the various solid and liquid inflammable substances, such as saw-dust, and melted rosin, &c., into moulds by a lever, screw, or hydrostatic press, into several neat and suitable forms of cakes, rings, &c. They appear to be so clean and free from smell, and really applicable for the various purposes for which they are intended, that any lady or gentleman may now light or revive their own fires without soiling their fingers.

A magnificent pair of shears, built up of wrought iron and worked by double cylinder steam crabs, has just been erected at "Hobb's Point," Pembroke Dockyard, by Messrs. James Taylor and Co., of Birkenhead, the firm that has supplied, under Admiralty Contract, the steam traction locomotives and steam cranes to Her Majesty's dockyard. The shears erected at Pembroke are 121ft. in height, and have been constructed to carry 75 tons, suspended from their greatest elevation. They passed their test most satisfactorily, under the supervision of Captain R. Hall, C.B., R.N., and Mr. J. J. Fincham, of Pembroke Dockyard.

A Big Blast.—At Shap Granite Works a short time ago a blast took place. With 75lbs. of powder, a solid block of granite, measuring 40ft. by 30ft. by 15ft., and weighing, 1,500 tons, was blown from the monster deposit of Wastdale Crag. Probably such an immense mass, in one block, has never been blasted before.

Important to Patentees.—The Lord Chancellor has decided a point of interest to the registrars of patents. An intending patentee had lodged a provisional specification, when another inventor filed one of a similar description, and procured his patent to be first sealed. The former complained of this, and argued that under the circumstances the Attorney General should not have allowed the second person to file his patent. The Lord Chancellor, however, pointed out that there was no law to compel a person who had filed a provisional specification to proceed with his invention, and if the applications of other parties were to be uniformly rejected, the country might be deprived of the fruits of the ingenuity of many minds which were working in the same direction.

A return of the number of vessels remaining on the register on the 31st day of December, 1868, has just been published in a parliamentary paper. The total number of sailing vessels of and under 50 tons in England and Wales was 7,502; above 50 tons, 12,309; of steam vessels of and under 50 tons, 884; above 50 tons, 1,337. In Scotland the number of sailing vessels of and under 50 tons was 961; above 50 tons, 1,964; of steam vessels of and under 50 tons, 146; above 50 tons, 374 In Ireland the number of sailing vessels of and under 50 tons was 947; over 50 tons, 1,018; of steam vessels of and under 50 tons 50; above 50 tons, 143. The number for each port in the United Kingdom and the Colonies are also given. The total placed on the register during the year 1868 1,110, of which number 36 were colonial-built and 62 foreign-built vessels. The total number of British and Foreign sailing and steam vessels that entered and cleared in English ports during the year 1868 was 299,695; Scotch ports, 52,887; Irish ports, 40,464.

Coal Cinders, and Culm.—A return moved for by Mr. Hussey Vivian gives an account of the quantities of coal, cinders, culm, and patent fuel shipped coastwise from the ports of England, Scotland, and Ireland severally; of the quantities exported from the same ports to foreign countries and British settlements abroad, and of the quantities brought coastwise into the port of London, and of the quantities received coastwise at the various ports of the United Kindom in the year 1867 and 1868. The exports in 1868 were—coal, 10,497,811 tons; cinders, 325,066 ton; culm, 14,927 tons—total, 10,837,804 tons; patent fuel, 129,258 tons. The duties on coal, cinders, and culm exported were wholly repealed by Act 13 and 14 Vict., c. 95, from 14th August 1850. The total quantities of coal received coastwise was 10,611,705 tons in 1867, and 9,751,990 tons in 1868.

Liquid Fuel as a Substitute for Coal.—Many are justly sceptical regarding the advantages which liquid fuel possesses as a steam-producing material for purposes of locomotion; but few, if any, will now deny its valuable properties as an agent for improving several manufactures, especially those connected with iron shipbuilding. A series of experiments were made at Chatham last May, to prove the capabilities of creosote in the process of plate bending, the results of which it may not be uninteresting to detail. Under ordinary circumstances—that is, when coal is burnt—it may be premised, an armour-plate-bending furnace requires to be lighted four or five hours before the plate to be operated upon is placed in it. One hour per inch of thickness representing the time occupied in heating the plate, it will be seen that if the experiment be made with a 6-inch plate, as in the case to which we are about to refer, 10 or 11 hours would elapse between the time the furnace was lit and the time the plate was ready for bending. In the experiments made at Chatham, on the other hand, the furnace was lit with the liquid fuel, and after an interval of an hour was sufficiently heated for the reception of the plate. A 6-inch plate, 7ft. 6in. long and 3ft. wide, was then placed in the furnace, and after an hour and an half was heated so as to be ready for bending. The supply of vaporised creosote was afforded to the furnace referred to from a generator by six jets, which are introduced by small openings, a sufficient quantity of atmospheric air to support combustion being admitted at the same time. In the case of another furnace for heating thinner plates, the liquid fuel, which was supplied by four jets, was drawn from the same generator as that mentioned in the case of the larger furnace. The average time occupied in heating half-inch plates by this means was seven minutes—twelve or fifteen minutes representing the time required when the ordinary method is employed. The rapidity with which the plates are heated is not the only advantage afforded by the system in which liquid fuel is used. The plates treated in the manner described were remarkably free from scale, owing to the absence of the deteriorating action of the products of combustion as they exist in the case or the ordinary furnace. The 6-inch armour plate mentioned above, had been three times in the furnace in which it was bent, and still preserved a clean, smooth surface. The advantage presented in the case of thinner plates when heated by liquid fuel and bent double is, that they do not crack, as is very often the case when coal is the heat-producing agent. It is stated that the saving effected by this means, by which deterioration is prevented, would amount to something like 10s. per ton of metal treated. The value of the system is also increased by the fact that in the process described the heat can be directed either to the whole or to a part of the plate, so that if it is necessary to bend only one end of it the heat can be applied to that particular portion. The rate at which the metal is heated can be accurately regulated either by increasing or diminishing the number of jets by which the liquid is supplied. The capabilities of the furnace with which the more important experiments have been made at Chatham will soon be more extensively tested when it has finished the work in which it will be shortly employed—namely, heating for bending the armour plates of the *Sultan*, a vessel of over 5,000 tons burden.

The Mobile *Register* describe some experiments recently made near that city, by which the following points were considered as established:—That the entire okra plant, from root to pod, is available for paper making; that it may be prepared in half the time required for rags; that the pulp works as easily as any other fibre,—and better than straw or wood; and that the paper is very strong, tough, and elastic.

The fastest time between California and Massachusetts has been made by a gentleman who arrived in Boston on Saturday from San Francisco, having accomplished the journey in seven days and eleven hours, including seventeen hours detention on the way.

It is said that the introduction of the water of the Mediterranean to the lakes by the Isthmus Suez has sensibly increased the hygrometric humidity of the atmosphere, and that fogs, as dense as those of Paris, have been observed in this rainless district.

The first invoice of tea from Japan for St. Louis was shipped on the 10th May, thus inaugurating the overland trade with China and Japan.

California Caoutchouc.—There is a caoutchouc tree in a thriving condition not far from San Juan South. The india-rubber tree has been generally considered a purely tropical production; but climatic conditions seem to be quite ignored in California.

### STEAM SHIPPING.

Mr. John Elder, of Fairfield Ship-building yard, Govan, has obtained the contract for constructing the engines of H.M.S. *Tenedos*, which is now been built at the Royal Dockyard Devonport. They are to be of 350-horse power, and are to be formed on Mr. Elder's patent expansion and condensing principles.

### LAUNCHES.

Launch of the "Invincible" Armour-clad.—A twin-screw armour-clad frigate for the British navy was launched from the building-yard of Messrs. Napier, at Glasgow, on Saturday May 29 noon. The *Invincible*, as the ship was named, is a twin vessel to the *Audacious*, launched by the same firm in February of the present year. She has been built from the from the designs of Mr. Reed, and her dimensions are:—Length between perpendiculars, 280ft.; extreme breadth, 54ft.; depth moulded, 36ft. Her burthen is 3,774 19·94ths tons o.m., and she will be fitted by the Messrs. Napier with twin-screw engines of 800 horse-power collectively. The armament is intended to consist of ten 12½ ton guns and four 64-pounders, six of the former being placed on the main deck, and the remaining four, with the 64-pounders, on the upper deck. The guns are to be concentrated within, and effectually protect by, a strong armour-plated battery, occupying the central part of the ship, and accommodating six of the heavy guns on the main deck, and four of those on the upper deck. The whole of the ten can be brought into action at once, and when necessary four of them can be trained forward or aft. The armour-plating of the vessel is of great strength. A broad belt of armour, eight inches thick (except at the extremites, where it is gradually lightened), covers the vicinity of the water-line, and the other parts of the sides and the battery have armour six inches thick, the backing being a 10in. thickness of East India teak, supported by a double plating of one and a quarter inches collectively, with strong girders and internal frames.

On the 9th inst. there was launched from the shipbuilding yard of John Elder, Esq., at Fairfield, Govan, the *Danube* an iron screw steamship of 800 tons, builders measurement. The engines which are of 120-h.p. are being fitted by the builder on his patent compound principle. The *Danube* has been built to the order of Donald R. McGregor, Esq., of Leith, and is intended for the Baltic and Mediterranean trades.

On the 8th ult., Messrs. Wingate launched from their building yard at Whiteinch a handsome screw steamer of 450 tons named the *Attalo* for the Asia Minor Steamship Company. The *Attalo* is fitted with compound engines of 80-h.p. nominal, Davidson's patent surface condensers, with all the latest improvements for economy of fuel, steam winches, steam windlass for raising anchors, also steam apparatus for hoisting small-boats, and other appliances for economising manual labour. She has also elegant passenger accommodation, and we have no doubt will prove a great acquisition to the fleet of the company. The ceremony of naming was performed by Miss Fanny Bell, daughter of Captain John Bell, Craigview, Ayrshire, principal partner of the company. On the 8th ult., the London and Glasgow Engineering and Iron Shipbuilding Company launched from their yard at Govan an iron screw steamer of the following dimensions:—Length—keel and forerake, 230ft.; breadth moulded, 31ft.; depth of hold from top to floors to upper side of upper deck, 22ft.—the property of Mr. Charles Williamson and others, Leith. As she glided from the ways, she was named the *Craigforth* by Miss Williamson, Edinburgh, niece of Mr. Williamson. The *Craigforth* was afterwards taken up to Glasgow to receive her engines, which are also being supplied by the London and Glasgow Engineering and Iron Shipbuilding Company on their compound principle. The design and arrangement of the machinery as adopted by this company combines in a peculiar degree simplicity and perfection in construction, all the parts being easily got at when an overhaul is necessary.

Launch of a Steamer.—There was launched, on the 12th ult., from the building yard of Messrs. Bowdler, Chaffer, and Co., of Seacombe, a very handsome iron screw steamer of 600 tons, builders' measurement, for Messrs. McAndrews and Co., of London and Liverpool, and intended for the Spanish trade. The vessel upon leaving the stocks was named the *Movatin* by Mrs. James McAndrews, the wife of one of the owners. The *Movatin* will be fitted with a pair of engines of 60-h.p. collectively, by Messrs. James Taylor and Co., of Birkenhead. These engines are on the compound principle of high and low pressure, and made from the designs of Mr. George Hepburn, of Liverpool, under whose superintendence both the vessel and engines have been constructed. She will be fitted with a patent windlass by Messrs. Napier Brothers, and will also embody in the remainder of her fittings all the latest improvements of the day. The builders have at present on the stocks two more similar sized vessels to the *Movatin*, for the same owners; also two sailing vessels of 1,100 tons each, and a screw steamer of 700 tons, in course of preparation, and intended for the Mediterranean trade. The *Movatin* is the sixth vessel launched from this yard within the present year.

On the 26th ult. Mr. John Elder launched from his shipbuilding yard, Fairfield, Govan, the *Cordillera*, a screw steam ship of 3,000 tons builders measurement, and 600h.p. nominal. The *Cordillera* has been built to the order of the Pacific Steam Navigation Company, is sister ship to the *Magellan*, *Patagonia*, and *Araucania* lately launched from the same yard, and is intended for the companys direct mail line between Liverpool and Valparaiso. Her engines which are being fitted by the builder are on his patent compound principle.

### TRIAL TRIPS.

Trial Trip of the "Elaine."—On Saturday afternoon, May 29, the fine new screw steamer *Elaine*, recently launched by Messrs. Harland and Wolff, Queen's Island, for Messrs. Frederick Levick and Co., of Newport and Newry, went on a trial trip on the lough. The machinery of the *Elaine* was fitted by Messrs. V. and D. Coates, of the Lagan and Princes Dock foundries. A number of gentlemen accompanied the builders and engineers on the trip, which was highly satisfactory. Both vessel and machinery worked remarkably well, attaining a speed of eleven knots an hour. Luncheon was provided for the company on board, and success to the ship and her enterprising owners cordially proposed and responded to. The entire ship, with her machinery and outfit, is the production of Belfast firms. It is intended with the *Elaine* to open up a steam coal trade between Belfast, Newry, and South Wales. On the Monday following, the *Elaine* left Belfast for her destination.

## RAILWAYS.

**The Pacific Railway.**—The *Economist* points out that it is doubtful whether the Atlantic Pacific Line will not, on account of its enormous length, afford the maximum of disadvantage to passengers, and thus favour existing routes by sea with a short land passage. The whole distance is given as 3,305 miles, and the time of the contiguous journey 6 days 17½ hours, which is probably a longer strain than the human constitution can stand. The railway journey from New York to San Francisco may be beyond the capacity of the large majority of men and women, unless with breaks, which, however, will greatly lengthen the time and diminish the special value of the railway. But apart from this difficulty, the expense will be a great drawback in competition with the sea routes. Emigrants, it is stated, can now travel from New York to California by the isthmus for £10, and the charge at present contemplated by the railway is approximately estimated at £30—to be reduced after the present month to £23. As this is 1⅗d of a penny per mile, a lower rate may be possible; but the expense of the isthmus route may also be reduced, so that the relative proportion will be preserved. The railway is certain enough to be of immense service, but it seems hardly possible that it will ever get more than a share of the New York and San Francisco passenger traffic. These difficulties will apply with greater force to the competition of the line for through traffic between Europe and China. Where the time is equal, or nearly so, the prospect of the long and expensive railway journey will keep travellers away, and this prospect will be a great obstacle to the use of the line even where the advantage of time is considerable.

**There** are fifteen hundred miles of railroad under contract in Indiana. That State has never made such progress in the construction of railroads as she is making this year.

**It** is stated that a meeting of the promoters of the project for a Brighton and Metropolitan Railway, which was introduced last autumn, was held a short time ago, and that it was determined to renew the application to Parliament for an act of incorporation in the ensuing session. Mr. Brunlees, the engineer, explained some modications in his plans of the mode by which the proposed line would enter Brighton, which he thought would be acceptable to the town and reduce the cost of construction.

**Train Signals.**—The French Government have paid great regard to the requirements of means of communication in trains between passengers and guards, and the successful trials of Mr. Weir's pneumatic system having occupied the attention of the Emperor and his Ministers of the Marine, of War, and of Commerce, an Imperial commission of four members was recently appointed to consider its capabilities. A short time ago M. Couche, one of the members deputed to represent the commission, accompanied by eminent railway engineers, arrived at Dover. A special experimental train of the full complement of seven carriages, forming the tidal service trains run by the London, Chatham, and Dover Company for the Paris through service, was courteously furnished by the directors; and the party, comprising several English engineers and other practical gentlemen, were conveyed to Canterbury (a run of 16 miles). Signals were repeatedly transmitted by the various members of the party under various circumstances, some times being very quickly repeated, in order to show the efficiency of this system for "talking" purposes. Since its trial before Colonel Yolland in February last, two important improvements have been made, namely, an automatic means (by the addition of a simple chain) of conveying a signal upon the accidental breaking away of any part of the train on the journey, and an equally simple means of making one and the same clockwork bell perform the two functions formerly assigned to two bells. By a little rod, merely turned from one side to the other, the alarum, which rings continuously in the guard's van on the pull of the passenger upon the signal lever in the carriage compartment, is stopped; and the bell afterwards—the gearing being altered—is struck only in single strokes upon each compression of the pneumatic chamber, so that the guards can repeat the blows in certain codes, like the beats of the electric needle, and carry on conversation with each other or with the driver. The whistle on the engine can also be actuated at the same time as the guard's bells by the one and the same pull of the passenger, who has no slack to draw in as the rope, nor any muscular effort to make, as in mechanical systems. Another value of the system is that the train can be conveniently started by these signals, and thus the efficiency of the practical apparatus can be tested before the commencement of the journey and at every stopping station along the line. The French commissioners appeared to be thoroughly satisfied with the action of the signals and with this system, bringing forward no objections whatever against it.

## DOCKS, HARBOURS, BRIDGES.

**Fleetwood.—Commencement of Docks.**—The commencement of these works began on the 2nd ult., when the first sod was cut. The formation of docks at Fleetwood will be of incalculable value in developing the maritime advantages and commercial conveniences of the proverbially safe harbour of the Wyer, and will materially contribute to the prosperity of the town and neighbourhood.

## TELEGRAPHIC ENGINEERING.

**Concessions** have been granted for a telegraph scheme to connect the British India telegraphic system with a line from Bangkok, through Siam and Cambodia, to Saigon, and thence to Cape St. James or Cape Padaran, from which a submarine cable will be laid to Hongkong. The privileges obtained include exclusive rights from the French authorities at Saigon for 40 years, the exclusive right of communication through Cambodia, and a concession from Siam for 90 years. It is anticipated to have Saigon in connexion with Europe before the end of next year, and that the connexion between Saigon and Hongkong may be established in the summer of 1871. The London agents of the parties interested are Messrs. Bremmer and Laycock.

A **Telegraphic** cable is nearly completed which will connect the islands of Scilly with the Land's End district. There will be two lightships placed at a given distance both to the south and west of the Scilly islands, and with these the cable will be connected. In the event of any homeward bound vessel making either of these lightships, she will be able to report her owners or their agents either in London, Liverpool, Whitehaven, or any other port of the United Kingdom, and to receive orders in many instances before leaving the Scilly Islands.

## APPLIED CHEMISTRY.

**To Remove Acid Stains and Restore Colour.**—When colour on a fabric has been accidentally or otherwise destroyed by acid, ammonia is applied to neutralize the same, a subsequent application of chloroform will, in almost all cases, restore the original colour. The application of ammonia, as above, is common; that of chloroform is but little known. Chloroform will also remove paint from the garment or elsewhere, when even, ether, benzole or bi-sulphide of carbon fail.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 76 | 0 | 0 | ,, | ,, | ,, |
| Tough cake and tile do. | 74 | 0 | 0 | ,, | ,, | ,, |
| Sheathing and sheets do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bolts do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 80 | 0 | 0 | ,, | ,, | ,, |
| Old (exchange) do. | 65 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 77 | 0 | 0 | 77 | 0 | 0 |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7 | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6½ | 0 | 0 | 6¾ |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. to arrive | 21 | 0 | 0 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 24 | 0 | 0 | 25 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 127 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 128 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 133 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 130 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 128 | 0 | 0 | 129 | 0 | 0 |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 5 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 11 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 2 | 6 | 4 | 0 | 0 |
| IX. do. do | 1 | 8 | 6 | 1 | 10 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 15 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 15 | 0 | ,, | ,, | ,, |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 0 | 0 | 8 | 0 | 0 |
| Bars do. do. | 7 | 7 | 6 | 8 | 0 | 0 |
| Hoops do. do. | 8 | 0 | 0 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | 6 | 5 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 7 | 5 | 0 | 7 | 10 | 0 |
| Do. Swedish in London do. | 9 | 17 | 6 | 10 | 0 | 0 |
| To arrive do. | 10 | 0 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 11 | 6 | 2 | 18 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 5 | 0 |
| Do. in faggots do. | 15 | 5 | 0 | 16 | 0 | 0 |
| English spring do. | 19 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 0 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 15 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | ,, | ,, | ,, |
| Spanish do. | 18 | 10 | 0 | ,, | ,, | ,, |

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*At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated May 19th 1869.

1538 W. Martin—Perambulators
1539 W. R. Lake—Gelatine
1540 G. Martin—Generating gases, &c.
1541 P. McGregor—Spinning
1542 J. T. Lucas—Velocipedes
1543 J. E., and A. Dowson—Foundations for piers, bridges, &c.
1544 A. W. Banks—Velocipedes
1545 W. Mitchall—Felted cloth
1546 D. Roberge—Shoes for horses
1547 G. V. Fosbery—Firearms
1548 F. Zysel—Velocipedes
1549 W. McAdam—Pottery
1550 W. M. Moore—Caps for bottles
1551 J. Langbsm—Ash pans
1552 W. F. Fuller—Securing the doors of safes and strong rooms
1553 J. Bowman—Fittings for window blinds
1554 A. J. Dudgeon—Propelling vessels
1556 A. L. McGavin—Propelling vessels
1556 A. L. McGavin—Constructing vessels, &c.

### Dated May 20th, 1869.

1557 Z. E. Coffin—Valves
1558 C. C. Parker—Cord tighteners
1659 G. Perkin—Castor
1560 A. A. Rossignol—Electric clocks
1561 J. Reid—Communicating between passengers and persons in charge of railway trains
1562 J. McMillan and J. McGregor—Preservation of iron
1563 M. Jarvis and E. Millward—Lock spindles and door knobs
1664 T. Herbert and J. C. Fowler—Conducting electricity, &c.
1565 H. E. Newton—Coffee mill
1566 J. P. Nolan—Measuring distances
1567 W. R. Lake—Boat-detaching apparatus
1568. G. Johnston—Spirituous liquors

### Dated May 21st, 1869.

1569 J. G. Tongue—Cutting wood
1570 S. Jackson—Window shutters
1571 E. H. Pulbrook—Organs
1572 W. H. Dupre—Ventilation
1573 A. Munro and W. B. Adamson—Treating metallic substances
1574 J. Platt—Brooms
1575 C. W. Siemens—Smelting ores
1576 A. M. Clark—Opening of eggs
1577 W. R. Lake—Shearing metal
1578 C. J. Foster—Obtaining reciprocating motion of the cutter bar, &c.
1579 N. Lawrence—Lighting cigars
1580 J. Hudson and C. Catlow—Looms
1581 W. Morris—Securing together the rails of railways

### Dated May 22nd, 1869.

1582 H. R. Lumley—Treating crude iron
1583 R. Orley—Bedsteads
1584 J. Lockwood—Couplings
1585 E. T. Hughes—Horse-shoe nails
1586 G. T. Bousfield—Casting iron
1587 J. H. Davis—Ships' compasses
1588 M. Tildesley—Sash pulleys
1589 S. Thomas—Envelopes for needles
1590 W. H. Bliss—Velocipedes
1591 L., J. Crossley and R. Hanson — Steaming yarns, &c.

### Dated May 24th, 1869.

1692 W. Furness—Improved clip
1593 W. Mitchell—Grinding metallic articles
1594 B. F. Weatherdon—Re acting turbine wheel
1595 W. A. Gilbee—Ice houses
1596 M. H. De Goesbriand—Steam motors
1597 E. T. Hughes—Brushes
1598 G. Salt and W. Inglis—Steam engine governors, &c.
1599 A. Barclay—Injecting liquids
1600 J. Brittain—Telegraphic instruments

### Dated May 25th, 1869.

1601 R. Richardson—Velocipedes
1602 J. Dick—Rolling mills
1603 J. H. Johnson—Billiard balls
1604 J. Trotman—Driving bands
1605 W. Jones and T. Sheffield—Drawing geometrical lines
1606 F. T. Blake—Obtaining motive power
1607 G. H. Hoare—Velocipedes
1608 A. McNeile and J. Slater—Improvements in carriage wheels
1609 L. Roman—Motive power
1610 R. Wheble—Hats
1611 R. Schomburg—Apparatus for receiving cigar ashes

### Dated May 26th, 1869.

1612 M. Benson—Cutting glass
1613 W. Palliser—Vents and screw nuts
1614 H. D. McMaster and A. Dale—Governor for steam engines
1615 T. Vaughan and E. Watteeu—Nutting screw bolts
1616 W. Tatham—Doffing, &c., the sliver of the carding engine
1617 C. E. Brooman—Bleaching vegetable fibres, &c.
1618 J. D. Brunton—Tunnelling, &c.
1619 C. F. Chew—Pianofortes
1620 J. J. Field—Microscope
1621 C. Hanson and J. Bottomley—Obtaining motive power
1622 J. Cranston—Glass houses
1623 J. Bridges—Lever lock
1624 G. H. Ellis—Cleaning boots
1625 R. P. Williams—Fishes for fishing railway rails
1626 F. H. Lloyd—Steel tubes
1627 E. G. Bartholomew—Electrical apparatus

### Dated May 27th, 1869.

1628 L., W., and J. Beesley—Improvements in boilers
1629 J. Snape—Pumps
1630 A. Edlmann—Manufacture of peat for charcoal
1631 F. S. Angel—Tablets for advertising
1632 F. A. Barrow—Purifying oils
1633 D. Foster—Hollow shot
1634 P. Whiteside—Mowing machines
1635 H. M. Ward—Spinning flax

### Dated May 28th, 1869.

1636 T. Bradford—Drying closets
1637 C. Plumb—Ratchet brace
1638 H. A. Bonneville—Photographic cartes
1639 B. T. Newnham—Carriages
1640 J. Wilson—Wooden railways
1641 J. Wilson—Wrought iron
1642 J. Bronner and H. Gutzkow—Obtaining anthracen out of asphaltos
1643 S. Prestwich and J. Prestwich—Improvements in velocipedes
1644 J. Ingham and I. Butterfield—Apparatus for dressing warps
1645 G. J. Pedley and H. Grabowski—Driving velocipedes, &c.
1646 W. R. Lake—Brushes
1647 W. R. Lake—Bolts and nuts
1648 G. F. Guy—Sheathing for ships
1649 T. Clarke—Velocipedes
1650 B. Garner—Bearings of axles
1651 F. Brown—Velocipedes
1652 A. T. Fairgrieve—Composition for coating the bottoms of ships
1653 J. Fraser, L. Simon, and R. Simon—Cutting pasteboard, &c.

### Dated May 29th, 1869.

1654 J. L. Hancock—Making hay
1655 J. L. Hancock—Clipping horses
1656 A. Hemingway—Slide valves
1657 E. J. Hughes—Preparation of cloth and yarn for printing
1658 W. H. Turner—Lessening the discharge of smoke from furnaces
1659 J. Humphrey—Iron keelsons
1660 J. Sturgeon—Machinery employed in getting coal, &c.
1661 J. M. Muterse and H. G. de Valory—Extinguishing fires
1662 A. A. Sax—Railway propulsion
1663 E. Davis—Velocipedes
1664 J. Smith—Holding the bobbins on the tubes of spinning frames
1665 J. F. Nicholls—Converting dining table into billiard table
1666 J. J. R. Humes—Brick moulds

### Dated May 31st, 1869.

1667 J. Cockshoot, jun., and H. Weatherill—Axles and axle boxes
1668 P. Kirk—Puddling furnaces
1669 H. T. Braithwaite—Velocipedes
1670 J. Hanworth and H. Horsfall—Furnaces for steam boilers
1671 R. S. Bartleet—Needle cases
1672 B. Littler—Guard for circular saws
1673 J. Bullough and C. Catlow—Improvements in looms
1674 C. E. Brooman—Boilers, &c.
1675 G. Preston and J. Prestige—Lamps
1676 R. Mathers—Supports for beds
1677 J. Dockray—Carding engines
1678 W. E. Newton—Novel device for locking stoppers in bottles
1679 D. Evans—Construction of ships, &c.
1680 J. King—Cinder sifter
1681 S. Birch—Fancy boxes
1682 W. R. Lake—Propelling and guiding vehicles, &c.
1683 H. Holdredge—Making gas
1684 J. H. Johnson—Stoves

### Dated June 1st, 1869

1685 F. A. Calvert—Obtaining motive power
1686 T. R. Clarke, W. Bywater, T. Lawson, and C. L. Lister—Felted fabrics
1687 A. Rushworth—Knitting machine
1688 C. H. Gardner—Lubricator
1689 O. Barret and G. P. Wheeler—Manufacture of mortar
1690 J. Warhurst—Closing the aperture of hinged doors, &c.
1691 H. Browning—Compositions for use as varnish
1692 J. S. Stubbs—Steam engines, &c.
1693 C. F. Waldo—Sewing machines
1694 J. A. Bindley—Attemperator for union and tunning casks

### Dated June 2nd, 1869.

1695 M. Wrigley—Prevention of accidents upon railways
1696 R. B. Cooley—Hats, &c.
1697 J. Fletcher—Steam cocks
1698 J. Urbain—Candles
1699 A. Watt—Printing surfaces
1700 G. V. Turnbull, C. Salvesen, and R. Irvine—Preparation of lubricants for the treatment of hemp
1701 B. J. B. Mills—Low-water indicator
1702 N., G., and E. Smith—Mode of cutting and skiving leather
1703 J. H. Smith—Velocipedes
1704 E. Bemelmans and A. V. Volxem—Signals of railways
1705 F. R. A. Glover—Anchors
1706 H. Larkin—Magnesium
1707 T. B. Worth—Carpets, &c.
1708 C. Francis—Waggons
1709 C. Francis—Moorings
1710 A. L. Simpson—Compositions suitable for treating sheep attacked by fly

### Dated June 3rd, 1869.

1711 C. Ostlund—Lamps
1712 B. F. Weatherdon—Safety bag
1713 J. Hopkinson—Artificial fuel
1714 W. R. Lake—Generating steam
1715 J. Lloyd—Fans for ventilating
1716 J. Stewart and T. Charlton—Improvements in multitubulous boilers
1717 F. Rave—Method of extracting colour from vegetable matter
1718 J. Tatham—Carding wool
1719 W. V. Morgan—Crucibles
1720 E. Rolfe—Utilising the exterior blank spaces of envelopes
1721 J. H. Johnson—Iron
1722 J. C. Norman—Agricultural implements
1723 C. W. Petersen—Lifeboats

### Dated June 4th, 1869.

1724 J. Edge—Steam engines
1725 E. S. Jones—Velocipedes
1726 E. T. Hughes—Wood-boring instruments
1727 J. Farmer—Mowing machines
1728 T. Best—Velocipedes
1729 W. H. Nicholson—Portmanteaus
1730 G. W. Ley—Ornamental articles in imitation of carving
1731 J. Duke—Cement
1732 E. M. Syer—Sleepers for the permanent ways of railways
1733 R. B. Plum and R. George—Sewing machines
1734 F. Lewis—Bottles for perfumes
1735 G. E. King—Fluted fabrics
1736 J. Blomfield—Sewing machines
1737 T. Wilkins and W. Fisk—Apparatus for slicing cucumbers, &c.

### Dated June 5th, 1869.

1738 A. B. Childs—Cleaning wheat
1739 H. Downie—Shoes for horses
1740 E. G. Brewer—Application of breaks to railway carriage wheels
1741 K. Cook—Cleaning grain
1742 T. W. Arkle—Extracting, &c., copper from water
1743 A. Wiglesworth—Curtain poles
1744 F. H. Holmes—Electro magnetic machines
1745 R. Law—Spinning frames, &c.
1746 A. C. Engert—Mouldings
1747 H. Kinsey—Surface condensers
1748 A. M. Clark—Motive power
1749 J., and S. W. Varley—Treatment of wool, flax, silk, &c.
1750 W. B. Leachman—Generating steam
1751 F. Hohmann—Sewing machines
1752 W. R. Lake—Reins

### Dated June 7th, 1869.

1753 G. G. A. Frebault—Electoral box
1764 C. Gall—Furnaces
1755 B. F. Weatherdon—Swivel-coupling for nautical purposes
1756 G. J. McKirby—Stile or biped pass for parks, &c.
1757 H. Smith—Reaping machines
1758 F. Heckner—Sawing machinery
1759 W. Sellers—Sewing machines
1760 G. Fenner—Bits for horses
1761 T. G. Greenstreet—Improved street sweeping machine
1762 W. E. Newton—Apparatus for folding printed paper
1763 E. Tavernier—Combing wool
1764 C. E. De Loriere—Linked buttons

### Dated June 8th, 1869.

1765 A. Williams—Stoves
1766 B. J. B. Mills—Obtaining lithographic compositions
1767 H. Carter and G. H. Edwards—Breech loading firearms
1768 D. Cole—Anchors
1769 M. Michel—Aerial navigation
1770 A. Gardiner—Checking the receipts of omnibus guards, &c.
1771 W. Cubley—Drawing boards
1772 A. M. Clark—Propelling vessels
1773 V. J. Four—Case for containing matches

### Dated June 9th 1869.

1774 W. E. Gedge—Treating leather
1775 R. Roberts—Dentistry
1776 D. J. Field and I. W. Lister—Compressing wool
1777 J. Mabson—Sewing machines
1778 A. J. Billing—Blind furniture
1779 W. Maddera and J. Wood—Machinery for embroidering
1780 J. T. Twigge—Velocipedes
1781 H. W. Hammond—Hammers
1782 A. St. Cyr Radiason—Treatment of fatty matters
1783 E. Bishop—Shears
1784 N. R. Hall—Weighing letters, &c.
1785 W. L. Wise—Artificial fuel
1736 W. Chambers—Refrigerating and ventilating carriages
1787 G. Johnson—Looms
1788 R. Harrison—Squaring slates

### Dated June 10th, 1869.

1789 C. Denbeigh—Velocipedes
1790 G. Fry—Treatment of wood
1791 G. Bedell—Re-adjusting locomotives thrown off metals
1792 J. Blair—Wadding
1793 J. Riley—Roofs, &c.
1794 T. Hodgson—Wire cloth
1795 J. Foster and J. Hollinrake—Prevention of smoke
1796 W. Cook—Photographic pictures, &c.
1797 W. R. Lake—Covering for floors
1798 W. A. Gilbee—Method of conveyance in pneumatic tubes
1799 J. G. Marshall—Velocipedes
1800 G. W. Oliver—Explosive powder

### Dated June 11th, 1869.

1801 W. A. Lyttle—Electro-telegraphic apparatus
1802 E. T. Hughes—Saws, &c.
1803 A. A. Ardisson—Stopping horses
1804 W. E. Newton—Drilling apparatus
1805 C. Stuart and W. Walker—Expanding ends of tubes
1806 J. Hill—Furnaces
1807 R. Duckworth, W. Greenwood, J. Pearson, and J. Langtree—Sizing yarns

### Dated June 12th, 1869.

1808 R. Wilson—Fasteners for neckties
1809 A. Lafargue—Weighing, &c.
1810 J. H. Riddell—Joints for securing together the ends of pipes
1811 G. W. Howe—Steam gauge
1812 J. H. Brown—Helmets, &c.

### Dated June 14th, 1869.

1813 C. Mather—Machinery for ginning and cleaning cotton
1814 W. R. Lake—Sewing machines
1815 L. H. Dennis—Cutting glass
1816 E. G. Brewer—Connecting pipes
1817 R. Brown—Iron
1818 J. Taylor—Floating and sliding top for wells, &c.
1819 W. S. Underhill and J. Smith—Reaping and mowing machines
1820 W. E. Newton—Attachment for and actuating ships' pumps
1821 J. Young—Slide valves
1822 J. G. Tongue—Shuttles
1823 W. R. Lake—Improvements in machines for sewing boots
1824 D. Fitzgerald—Firing projectiles from a cannon, &c.

### Dated June 15th, 1869.

1825 P. Jensen—Improvements in the manufacture of glass
1826 A. W. Moss—Brims or sunshades for attaching to hats
1827 F. Lejeune—Weighing machines
1828 M. Benson—Planing wood
1829 M. Benson—Mortising machines
1830 M. Benson—Band sawing machinery for sawing wood
1831 F. C. Bakewell—Letter printing
1832 W. Smith—Purifying mineral oils
1833 J. Bastow—Bleaching yarns
1834 J. Lindley—Oiling the axles of trucks or waggons, &c.
1835 H. Bathgate—Effecting communication between railway passengers, &c.
1836 W. Yates—Furnaces
1837 W. Bottomley—Footsteps, &c.
1838 R. Beecroft—Combing wool
1839 J. Halliwell—Improvements in hold-backs for carriages
1840 J. T. Mashon—Apparatus for carrying invalid persons
1841 T. Knowles—Doubling frames
1842 H. Tylor—Spring mattresses
1843 C. Stuart—Pulley blocks
1844 R. McHardy—Agricultural and garden implement
1845 D. Dishart—Sewing machines
1846 J. Tangye—Governors or regulators for steam engines
1847 B. Wartski—Waterproof overcoats
1848 S. V. Fontana—Harmoniums
1849 W. R. Lake—Producing an enamelled surface upon sheet iron

### Dated June 16th, 1869.

1850 G. W. Fox—Treatment of castor and cod liver oils, &c.
1851 R. Hornsby and J. E. Philips—Reaping machines, &c.
1852 R. Hornsby and J. E. Phillips—Hay making machines
1853 W. Woofe—Ploughs
1854 E. Cardon—Improvements in the construction of ships
1855 T. Routledge—Materials for the manufacture of paper
1856 A. Destouy—Apparatus for sewing boots and shoes
1857 W. E. Newton—Cleansing and preparing rags, &c.
1858 B. Hunt—Apparatus for ventilating and purifying rooms
1859 C. Marlor—Improved pad for hats, and other coverings for the head
1860 W. R. Lake—Method of counting stitches made by a sewing machine
1861 J. Kirk, S. Shelmerdaine, and C. Froggatt—Felting hats
1862 J. H. Banks—Convertible desks

### Dated June 17th, 1869.

1863 J. Harding—Mail bags, &c.
1864 W. McNabb—Fasteners for bands
1865 J. H. Johnson—Improvements in picks, &c.
1866 J. H. Johnson—Sugar
1867 C. and E. Brightman—Shoes and boots
1868 W. R. Lake—Preparing sulphates, &c.
1869 W. R. Lake—Stoves, &c.
1870 S. Adams—Velocipedes

W.Smi

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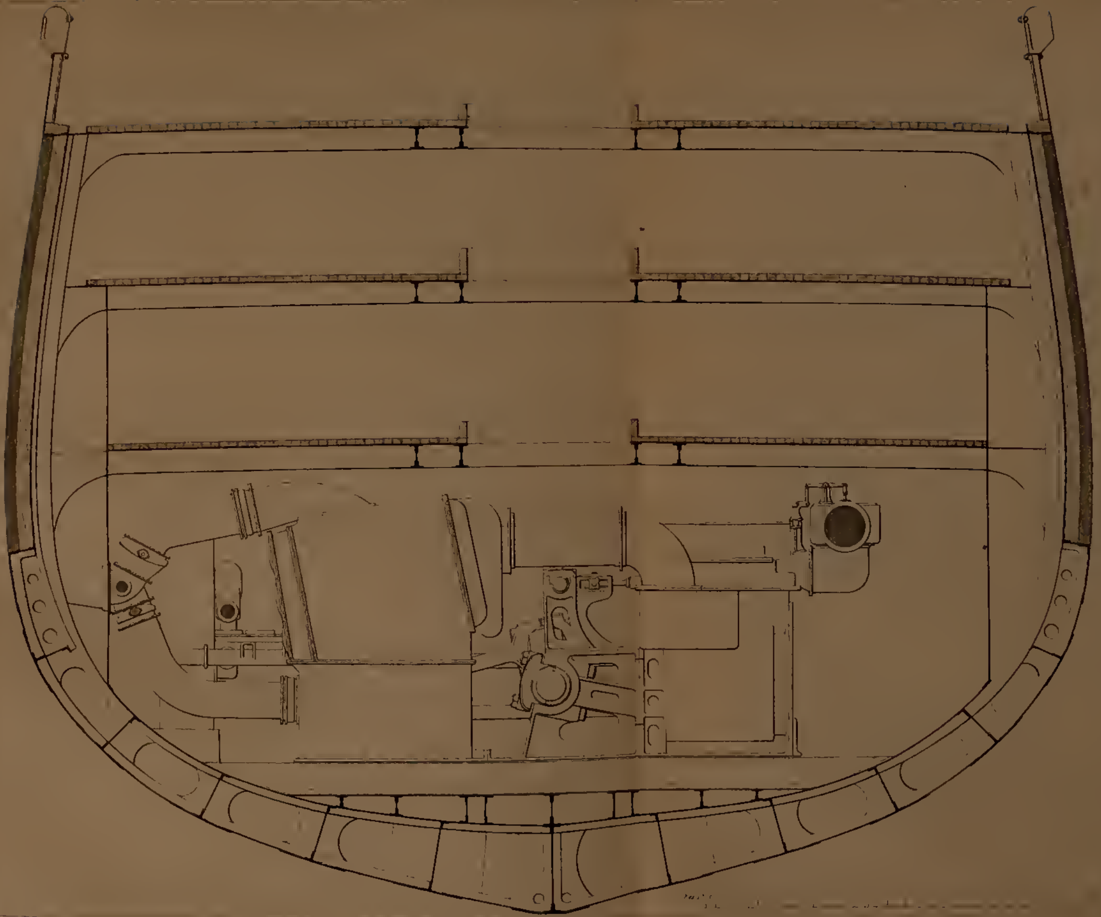
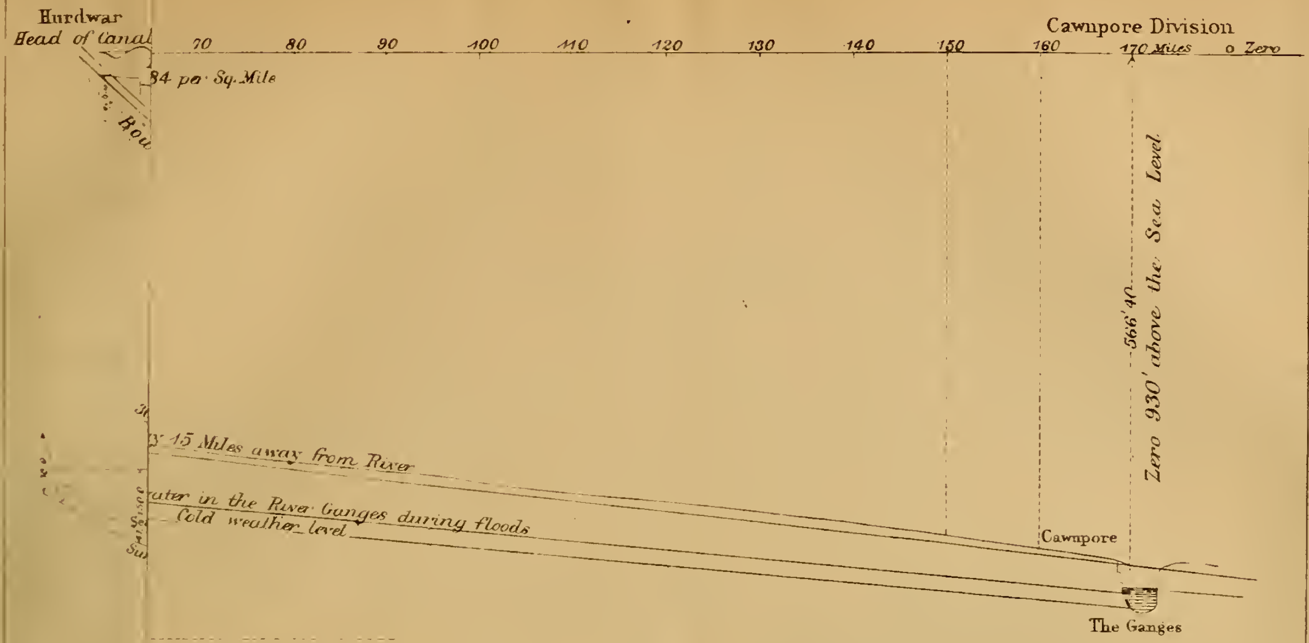


Smith. C E direx



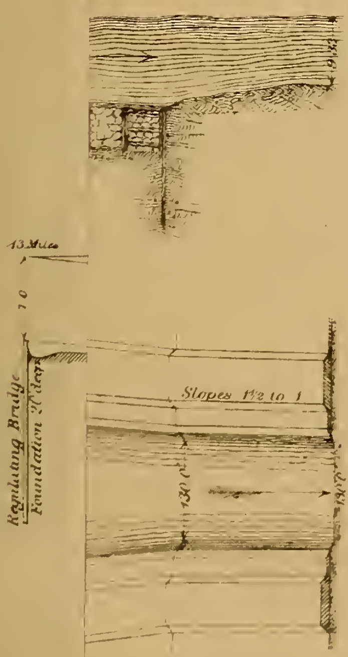
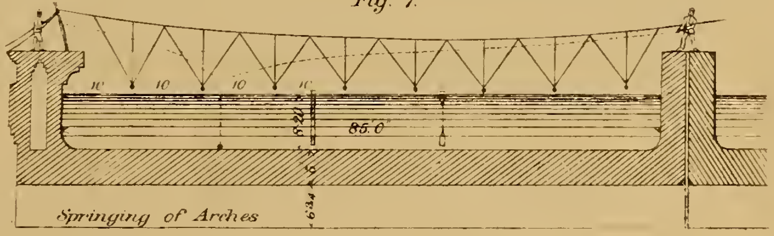


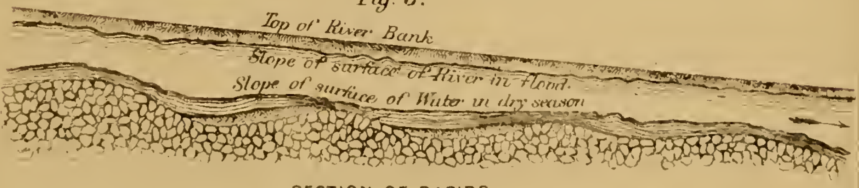
Fig: 7.



HALF SECTION OF THE SOLANI AQUEDUCT.

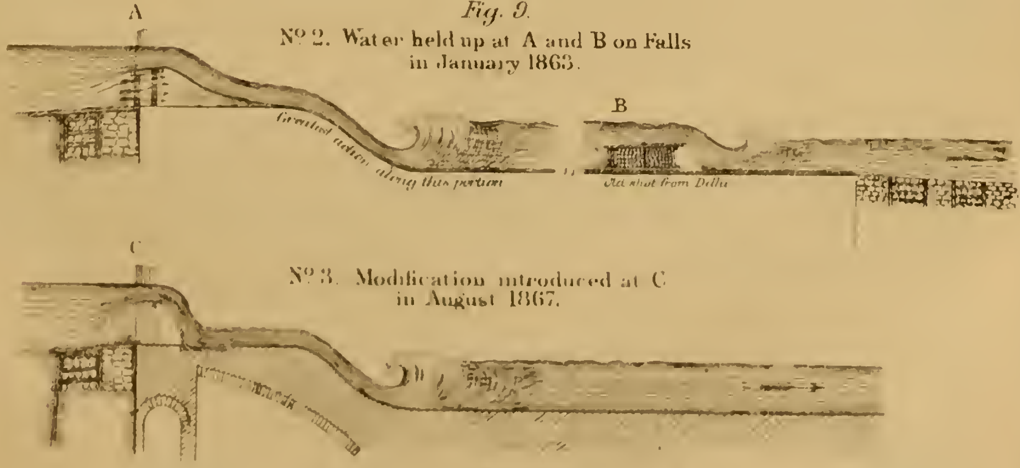
Scale
Feet 10 5 0 10 20 30 40 50 60 Feet

Fig: 3.


Top of River Bank
Slope of surface of River in flood.
Slope of surface of Water in dry season

SECTION OF RAPIDS.

Fig. 9.


A
N° 2. Water held up at A and B on Falls in January 1863.
Greatest action along this portion
B
Old shot from Delhi
C
N° 3. Modification introduced at C in August 1867.

SECTIONS OF THE GANGES CANAL FALLS

Scale
Feet 10 5 0 10 20 30 40 50 60 Feet

W SMITH

# IRRIGATION IN INDIA.

Fig 6

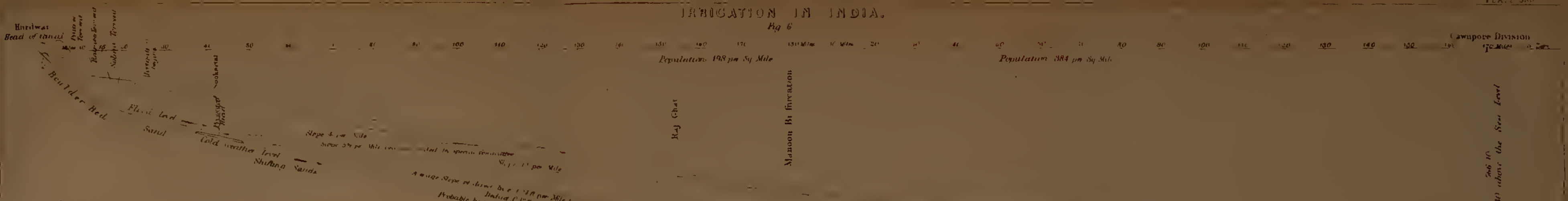
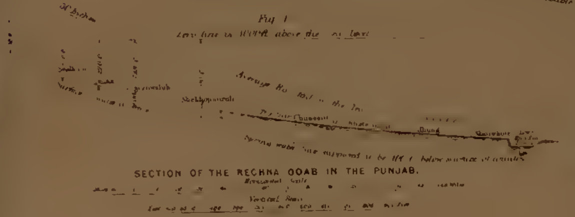
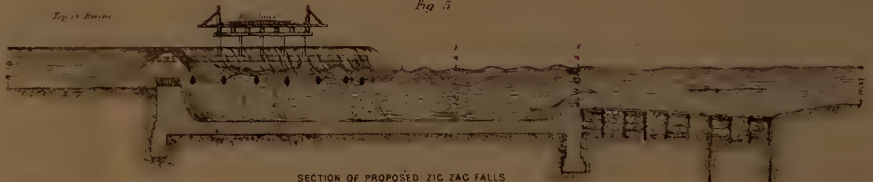


Fig 1



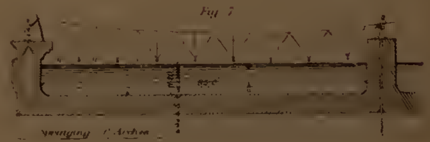
SECTION OF THE RECHNA DOAB IN THE PUNJAB.

Fig 5



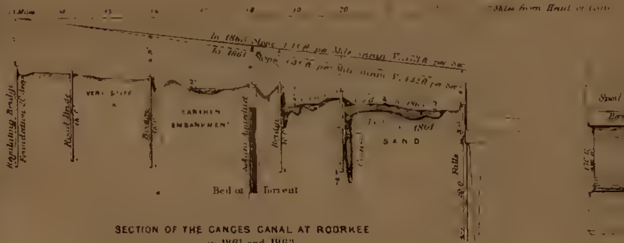
SECTION OF PROPOSED ZIG ZAG FALLS

Fig 7



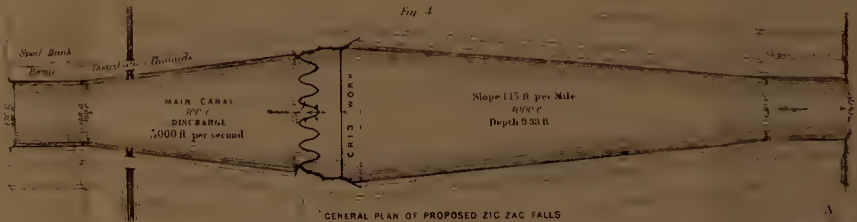
HALF SECTION OF THE SOLANI AQUEDUCT

Fig 2



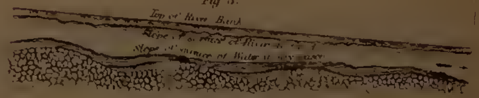
SECTION OF THE GANGES CANAL AT ROORKEE in 1861 and 1863

Fig 4



GENERAL PLAN OF PROPOSED ZIG ZAG FALLS

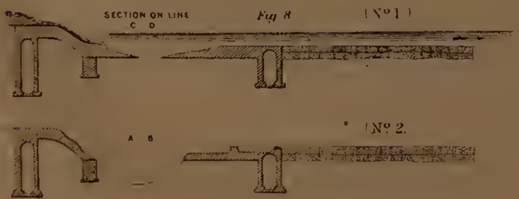
Fig 3.



SECTION OF RAPIDS

Accident to Falls in 1862

Fig 8



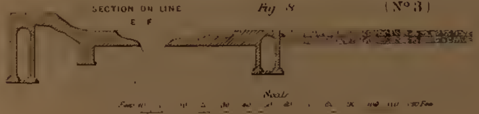
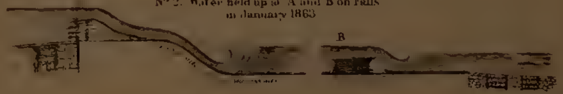
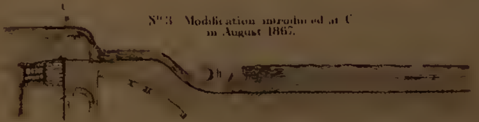


Fig 9



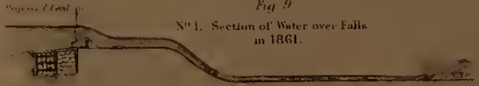
No 2. Water held up to A and B on Falls in January 1863



No 3. Modification introduced at C in August 1867.

SECTIONS OF THE GANGES CANAL FALLS

Fig 9



No 1. Section of Water over Falls in 1861.

# THE ARTIZAN.

No. 8.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. AUGUST, 1869.

## SAUNDERS' FLOATING BREAKWATER.

By Messrs. Walpole, Webb, and Bewley.

(*Illustrated by Plate* 351).

The vital necessity for the formation of harbours of refuge in exposed situations has, perhaps, stimulated the civil engineering talent of this country more than any other kindred subject. Undertakings of this description are usually not only gigantic, but the conditions under which they must necessarily be constructed, are extremely variable, and always difficult. As a natural consequence, the opinions expressed by different engineers upon the construction and conformation of breakwaters are equally various; while in practice it will be found that scarcely any two breakwaters in Great Britain or France bear any resemblance to one another. Of course, we do not take into account the cost of construction, as in that particular they bear a wonderfully close resemblance—in fact a family likeness. The celebrated Plymouth breakwater, which required 3,369,261 tons of stone for its construction, cost about 1¼ millions sterling, and although it would not be safe to estimate the cost of those at Cherbourg, Alderney, and Dover, they may each be put down for a very much larger amount. When, however, the protection to life and property afforded by breakwaters is taken into account, they must be considered cheap whatever may be their cost. A more formidable objection to the formation of breakwaters as at present constructed, is to be found in the enormous length of time they take in erection; thus the Plymouth breakwater took a whole generation to build it, and as to the Alderney and Dover breakwaters, although commenced many years ago, we should be extremely sorry to fix any date for their completion. This immense expenditure of time and money is easily accounted for by the fact, that during heavy weather the force of the waves against an immovable surface—or rather a surface that it is intended to be immovable—not unfrequently amounts to more than 6,000lbs. per square foot. It is evident, therefore, that should a heavy gale occur during the formation of the breakwater, when the masonry is not set, and before the weight of the upper portion can be made effective, it will almost certainly be damaged to a great extent; hence arises a fruitful source of expense and delay.

In order to obviate the necessity of encountering such dangers and difficulties, many plans have from time to time been contrived. Thus, as early as the year 1783, a breakwater was commenced at Cherbourg, under the superintendence of M. Cessart, who suggested the use of large wooden truncated cones placed base to base and loaded with stones. They were built on the land and floated by means of casks to their destined position, and then filled with stone and sunk. The bottom of each cone was 150ft. in diameter, the top about 64ft. in diameter, and the height about 70ft., of these eighteen were actually sunk, but were, contrary to M. Cessart's design, placed at considerable distances apart. The life of this breakwater was a very short one, those cones that were the furthest from any other suffered most, and were entirely broken up within a year of their immersion, while the whole of them disappeared in less than four years. About twenty years ago Mr. N. Beardmore proposed to obviate the danger of building breakwaters *in situ*, by employing large wrought iron caissons upon which the breakwater was to be built in some sheltered place, and afterwards towed to its destination and sunk bodily; the iron caisson forming the foundation of the breakwater. Other somewhat similar plans, such as confining the material in wooden boxes, &c., have also been employed for a like purpose. In all of these various designs the principle upon which the breakwater is constructed, is the same, viz., that of opposing force to force, or in other words, of entirely banking out the water of the ocean from that of the harbour by making a wall impervious to water, and of sufficient strength to withstand the shock of the waves. About forty years ago Mr. White proposed the adoption of a floating breakwater, which consisted simply of several balks of timber fastened securely together, and moored by means of one or more anchors and chain cables. This form of construction was evidently founded upon the idea that the agitation of the water is purely superficial, and therefore it was sought to cover as large a horizontal area as possible. There is no doubt that the destructive action of the water during a gale diminishes rapidly with the depth, but it is equally certain that such action is effective at a depth considerably greater than the draught of a balk of timber. A somewhat similar floating breakwater was proposed by Mr. A. W. Sleigh, the only difference being that the upper surface was inclined upwards from the waves to prevent them breaking over the structure. Mr. Macnamara also proposed a modification of the same plan, consisting of a double row of tubular vessels, or pontoons, closed at the ends, but in neither of these schemes was any provision made for affecting any portion but the surface of the water.

In direct opposition to this system, may be mentioned the vertical wave screens, such as those proposed by Mr. Calver, Mr. Brunlees, and others. Mr. Calver's design consists of a row of vertical piles driven firmly into the bottom at certain distances apart. They are united horizontally by iron runners, and are each supported laterally by two sloping struts, having large iron shoes at their lower ends for the purpose of entering and abutting against the bottom, while their upper ends are connected with the main upright piles by swivel joints, to admit of their being placed at any required angle. The shorter strut abuts against the pile a little above low water, and the longer strut a corresponding height above high water, a short chain extending from the place where the lower strut joins the main pile to the longer strut. The shoes of the struts are made of such a shape that they present a vertical flat surface to the soil in which they are buried while they are not to be driven into the soil, but buried beneath the surface by the tidal current. This form of construction is calculated by Mr. Calver to be able to withstand any force to which it would be likely to be exposed. A somewhat similar idea was proposed by Mr. Brunlees, in which the piles are placed zig-zag at an angle 90° for the purpose of increasing the resisting power. The spaces between the piles are to be partially filled by louvre boards, the distance between these boards being considerably greater towards the bottom to avoid interfering with the run of the tide. Mr. W. B. Hays also proposed a series of inclined planes or platforms, which were to be fixed between a straight row of piles; in this case the planes were to be considerably wider than that just described, but the idea appears to be very similar. Various other plans have from time to time been proposed for the same purpose, viz., of breaking the force of the waves without subjecting the structure to an excessive strain. Thus, Mr. Dendy proposed an upright tubular or cellular structure, secured by piles spaced at regular intervals, to effect that object, and Mr. M. Scott suggested the employment of a long inclined plane with spaces between for the water to rush through. Mr. W. H. Smith adopted the *flecti non frangi* principle, and proposed a solid upright timber breakwater fastened by means of hinged joints, so that it might sway backwards and forwards with the waves. In his design a gangway is shown running along the top of the structure, but we doubt whether any person could be found sufficiently bold to venture upon it rough weather.

It will be seen from the above description of the various designs for fixed wave screens, that, with the exception of the last mentioned absurdity, the object endeavoured to be attained is the breaking up of the waves sufficiently to eliminate all danger from them, with the smallest possible resistance to them. It is difficult without actual experiment to calculate what strain any of these structures would be required to withstand in order to accomplish their object, as the degree of obstruction that would be required to be opposed to the water to effect the desired object is not yet ascertained. When, however, we remember that a force of more than 6,000lbs. per square foot has to be provided against, it is clear that any designs for fixed breakwaters would have to be built immensely strong to withstand the battering of the waves even when built with a very small opposing surface, and consequently the expense of such a structure must be very considerable.

The question then arises whether it is not possible to construct a floating breakwater of such a form that it shall not only be effective against the surface waves, but shall extend to a sufficient depth to be effective against the heavy rollers caused by a gale. It is a well known fact that the heaviest gale does not disturb the water to any considerable depth, and it was no doubt to a partial knowledge of this peculiarity that the floating breakwaters already mentioned, owe their existence. It has, however, been found that the destructive force of the waves is not confined entirely to the surface, and Mr. Airy, the Astronomer Royal, has calculated that at a depth equal to the length of a wave the motion is $\frac{1}{535}$ of that at the surface. It is also found in practice that in building a solid breakwater, the wall need not begin at a level of more than 12 to 15ft. beneath the surface at low water as, according to Mr. Rendel, the waves appear to do little or no damage to *pierres perdues* at that depth. It appears to be necessary, therefore, that a floating breakwater should be so constructed that it would not only destroy the force of the surface waves, but extend to a sufficient depth to stop all dangerous waves. Upon reference to Plate 350, a floating breakwater designed by Mr. Saunders is there illustrated, which evidently satisfies these conditions. It consists of a number of vertical bulkheads gradually increasing in depth from the seaward to the landward side; so that the breakwater in vertical cross section presents the form of a wedge with its edge towards the sea. The water has perfect freedom for vertical motion between the divisions, but it cannot make horizontal progress or affect the water in the neighbouring division, so that the wave motion cannot be propagated, or the water make landward progress, except in the form of broken water or spray—thus the whole force of the running sea is lost. From the formation of the breakwater, as will be seen upon referring to Plate 351, the wave in its advance strikes in succession on each bulkhead; and thus its force is spent gradually instead of being accumulated in one violent blow, as against an ordinary fixed breakwater. The mass of comparatively still water that is comprised between the numerous bulkheads, together with the broad vertical surface against the smooth water on the landward side, makes it impossible for the blow of a wave to bring any sudden jerking strain upon the moorings, and as the height above water is very small, the strain upon the moorings due to the wind would be very trifling. The depth of immersion on the landward side is about 18ft., and as we have already shown that the depth to which a storm dangerously disturbs the water is found to be from 12 to 15ft., it is evident that such immersion will be fully adequate for any emergency. The power of flotation is obtained either by inclosing the two outside bulkheads (shown in Plate 351), so as to make them into water-tight chambers or pontoons, or by making a series of transverse pontoons, which at the same time stiffen the vertical bulkheads. The mooring may be effected either, as shown in Plate 350, by means of booms jointed at the bottom and having india-rubber compressors or springs to admit of a slight yielding motion to the breakwater; or it may be moored in the usual manner by chain cables, which we consider would be a more preferable arrangement.

For shallow water Mr. Saunders proposes a fixed breakwater which, with the exception of the pontoons for the purpose of flotation, is precisely similar in construction to the floating breakwater, but instead of mooring chains, an iron framework resting upon the bottom, supports it. This framing is made considerably wider at the base, which is also provided with longitudinal angle, or T irons, having their edge downwards, which are consequently buried in the soil and prevent any lateral motion of the breakwater.

There is no doubt but that a floating breakwater, if it can be made efficient, offers immense advantages over the fixed description, for it is evident that the cost would be very much less, while it could easily be made in a few months. The principal advantage, however, appears to consist in its applicability for shipment abroad, as the parts being all straight and thin, could be packed in a very small compass, while it could could be very easily put together at its destination. There are many exposed places on the coasts of India and some of our colonies, where a breakwater of this description would be an inestimable boon, and where we have no doubt it might be moored with the greatest facility.

## ROADS, RAILWAYS, AND CANALS IN INDIA.

(*Concluded from p.* 149.)

At page 147 *ante*, in the first paragraph, reference is made to the cost of doubling and maintaining the railway as compared with the cost of making and maintaining a canal—the railway there referred to is the East Indian Railway.

Adhering to the table of rates given at page 123 *ante*, it is shown that where grain costs only one rupee a maund, the cost of this grain when transported 300 miles would be enhanced in price as follows:—

| | |
|---|---|
| By navigable canals............................... | 20 per cent. |
| „ railway ............................................ | 39 „ |
| „ carts on metalled roads ................... | $76\frac{3}{4}$ „ |
| „ „ country roads........................ | 100 „ |

with no allowance for back hire.

It is also shown that for all goods costing less than Rs. 14 a maund, water carriage would be preferable where time was not of much importance.

3rd. That, independent of the cost of the carriage of camp equipage, troops can be conveyed by rail at one-tenth the cost, and in $\frac{1}{25}$th the time of marching on roads.

Lastly, to enable other metalled roads throughout India to be compared with this portion of the G. T. road, north of Delhi, it may be further stated that the cost of consolidated metal has been Rs. 16-1-11 per 100 cubic feet during the last two years, independent of the cost of the establishment, native or European. By comparing this rate, which includes collection and consolidation (consolidation reduces the cubical contents one-third), with the rates in other parts of the country, a nearly correct estimate can be arrived at of the cost to government in keeping up metalled roads for the transport of goods.*

---

* To compare other roads with that between Delhi and Umballah, we may take a favourable example where the cost of metal is low.

| | | | |
|---|---|---|---|
| Supposing the cost to be compensation to Zemindars, at ...Rs. | 0 | 4 | 0 |
| Cost of digging, at Rrs. 2 ..................................... | 2 | 0 | 0 |
| Cost of carriage, of 3-8 (6 miles),........................ | 3 | 8 | 0 |
| Stacking at road side, at Rs. 0-4-0, ..................... | 0 | 4 | 0 |
| Consolidation, at Rs. 1 ......................................... | 1 | 0 | 0 |
| Tools, at Rs. 0-2-0 .............................................. | 0 | 2 | 0 |
| Total per 100 cubic feet...... | 7 | 2 | 0 |
| These 100 cubic feet, on being consolidated, becomes reduced to $66\frac{3}{4}$ cubic feet = ...................................... | 7 | 2 | 0 |
| Add one-half $33\frac{1}{2}$ „ „ = ...................................... | 3 | 8 | 0 |
| Total, 100 „ „ = ...................................... | 10 | 11 | 0 |

or one-third may be deducted from the rates on the 7th Division, G. T. Road, for maintenance; or the cost would be Rs. 0-2-1 for 100 maunds a mile, the very same as the charges on the railway.

The following interesting table, which has been carefully collected by Mr. Login, will be referred to shortly in dealing with the following subject:—

Register of Traffic over the 7th Division, G. T. Road, 5 miles South of Kurnaul, from 9th Jan., to 28th Feb., 1867, inclusive.

| Number. | Description. | Total traffic over Road. | Per centage up. | Per centage down. | Preferable description of conveyance. | Remarks. |
|---|---|---|---|---|---|---|
| | | Maunds. | | | | |
| 1 | Iron for Delhi railway | 94,046 | 100 | ... | Canal | This traffic is only temporary, and therefore should be kept separate. |
| 2 | English and native iron for general purposes | 4,303 | 80 | 20 | Canal | The down traffic in iron is brought from Ferozepore by cotton return carts. |
| 3 | Stores, chiefly English | 18,007 | 80¼ | 19½ | Rail | Valuable stores, packed in boxes, &c. |
| 4 | Spirits, beer—in casks | 5,972 | 100 | ... | Canal | Chiefly for European troops. |
| 5 | Cloths, of sorts | 2,319 | 82½ | 17¼ | Rail | Chiefly English goods. |
| 6 | Tents and camp sundries | 14,843 | 77 | 13 | Roads | This depends on the movements of troops. |
| 7 | Tobacco | 1,682 | 57 | 43 | Rail | This chiefly depending on different markets. |
| 8 | Ghee | 42 | ... | 100 | Rail | Ditto. |
| 9 | Oils | 36 | ... | 100 | Canal | Ditto. |
| 10 | Cotton | 4,491 | 93 | 7 | Canal | Exported to England *viâ* Ferozepore chiefly. |
| 11 | Salt | 4,623 | 53 | 47 | Canal | Up traffic from west of Delhi; down traffic rock salt from Salt-range. |
| 12 | Hides | 973 | 15 | 85 | Canal | Chiefly for exportation. |
| 13 | Bazaar sundries | 6,519 | 61 | 39 | ⅓ C., ⅓ Rl., ⅓ Rd. | Chiefly local traffic. |
| 14 | Tea | 581 | 90 | 10 | Rail | Chiefly for European troops. |
| 15 | Fruits | 1,887 | 8 | 92 | Rail | Up traffic, chiefly oranges from Delhi; down, chiefly Cabul fruit. |
| 16 | Timber | 1,807 | 47 | 53 | Canal | Local, up and down, depending on description of wood. |
| 17 | Firewood | 3,347 | 55 | 45 | Canal | Local, for the use of Kurnaul and Paniput, as well as encampments. |
| 18 | Charcoal | 1,011 | ... | 100 | Canal | Sent to Delhi. |
| 19 | Bamboos for thatching | 662 | 56 | 44 | Road and canal | Local. |
| 20 | Manure | 76 | 100 | ... | Road | Local. |
| 21 | Grass and fodder | 9,475 | 18 | 72 | Road | Local. |
| 22 | Grain | 11,141 | 42 | 58 | Canal and road | Local at times, but depending on seasons. |
| 23 | Stone | 1,322 | 100 | ... | Canal | Small hand mill-stones, for sale throughout the Punjab. |
| 24 | Limestone | 110 | ... | 100 | Canal | Local. |
| 25 | Brass and copper | 477 | 80 | 20 | Rail | For sale in the Punjab. |
| 26 | Zinc and tin | 161 | 100 | ... | Rail | Ditto. |

Remarks.—These rates are believed not to be more than two or three per cent. above or below the actual weight.

The foregoing statistics are obtained from a register of the traffic over the Grand Trunk road at the bridge over the canal, five miles south of Kurnaul, from 9th January to 28th February, 1867, both days included, which shows a daily average traffic of 4,245 maunds up and down the road; of this traffic, however, 43½ per cent. was the carriage of iron for the Delhi railway, and as this is only of a temporary nature, it should properly be excluded from the calculations in striking an average. Also, it should be observed, the register was kept at the season when there is the greatest traffic during the whole year. Again, taking the register near any large town must tend to enhance the local traffic, for which allowance should be made. There was a register kept by the civil authorities at the same time, four miles south of this place, Umballah; but on commencing to abstract the information this register gave, Mr. Login found it impossible to check the one with the other, as the classification was not the same as that kept south of Kurnaul, and the approximate loads of the carts were not entered. For example, the iron brought by Messrs. Brassey, Wythes, and Henfrey, for the Delhi railway, was mixed up with other iron brought for the market, and as a large proportion of this railway iron was taken by a branch road some fifteen miles south of Umballah direct to the railway, no comparison could be effected. Also the local traffic near Umballah was much affected by the carting of fire-wood for the numerous brick-kilns at and near the station; so all the useful information from this register, that Mr. Login could obtain was, that the number of carts conveying cotton to Ferozepore, was more than double as many as passed over the canal bridge. This was to be expected, as cotton was being carted from Kurnaul, Ladwah, Jugadree, and Saharunpore to Ferozepore, to be boated down the Indus, while the other register could only show what cotton was brought from Delhi and Paniput.

Traffic over the Canal Bridge, near Kurnaul.

| Slow Traffic. | Laden. | Return empty. | |
|---|---|---|---|
| Native carts | 5,185 | 2,831 | Probable weight represented by 1st column, 1893 maunds daily. |
| 4-wheeled wagons | 516 | 283 | |
| „ light shigrams, wagons | 770 | 469 | |
| Packhorses and mules | 158 | no return | |
| „ asses | 2,140 | „ | |
| „ camels | 847 | „ | |

TRAFFIC OVER THE CANAL BRIDGE, NEAR KURNAUL.

| Quick Traffic. | Maunds. | Total Maunds. | |
|---|---|---|---|
| Passenger bullock carts, 798, at…………………… | 15 each | 11,970 | Weight, 506 maunds daily. |
| Horse dâk carriages, 832, at ……………………… | 15 each | 13,876[*] | |
| | | 25,845 | |

Taking these returns as being correct within reasonable limits, we get as follows:—

Total traffic over the road daily, during the months of January and February, 1867, was

Quick traffic………… 506 maunds.
Slow ditto……………… 1893 „
Add $\frac{108800}{59}$ = …… 1844 „ for Delhi railway iron.[†]

Total average … 4243 maunds, or 151½ tons.

It has been above shown that the cost of maintenance of one mile averages £200, or 2,000 rupees a year, that is $\frac{2000}{365}$ = Rs. 5-7-8 daily; and for this expenditure, 4,243 maunds are transported,

∴ as 4,243 : 100 : : Rs. 5-7-6 : Rs. 0-2-0·8.

That is, it costs Government nearly as much to keep up the road as if all the traffic went by rail, Again, as the East India Railway now returns 6 per cent., Government receives ½ per cent. of this profit, and taking the working expenses as one-half of the actual fares, Government receives $\frac{1}{24}$th of this. Now $\frac{1}{2}$th of the whole returns for the cheapest description of goods is $\frac{\text{Rs. 0-2-1,}}{24}$ which equals one pie nearly, and if we add this loss to the above, it amounts in all to Rs. 0-2-1·8, or more than the railway rates. As the traffic has all been calculated as *dead* weight of the lowest class, and not as passengers or higher classes of goods, which would pay considerably more, it is evident, that in keeping up metalled roads instead of railways or navigable canals, both Government and the country are losers, even not deducting the cost of transporting the Delhi Railway Stores.

If the proper deductions be made on account of this temporary extra traffic for the Delhi railway, and allowance be made for the season of the year at which this register was kept, the actual traffic would barely average 100 tons daily (instead of 151⅓ as now calculated), or 2,800 maunds, which would enhance the rate by one-half more.

For simplicity, and to be within limits, we may take the expenditure on maintenance of a mile of road at 5 rupees, or 10s. daily, and the traffic at 100 tons, that is Rs. 0-3-1½ per 100 maunds a mile, or very nearly a 1¼d. a ton. Again, taking this latter rate of a 1¼d. a ton a mile, we find that the cost of conveying one ton from Delhi to Calcutta (in all by rail, 1,022 miles), taking the distance at 1,000 miles, we have the cost of maintaining the road at the rate of £5 4s. 2d. a ton, or a little over a halfpenny a pound. Then, taking the cost of carriage at Rs. 0-6-0 per 100 maunds a mile, which is now very near the actual rate, the cost of transport from Delhi to Calcutta by carts would be $\frac{100}{28} = 3{\cdot}57$ tons, cost Rs. 0-6-0 a mile; or one ton costs 2½d. a mile, or about 1d. a pound more, thus adding a 1½d. a pound to the cost of all raw material produced, not to speak of the delay and deterioration by the way.

With railways, on the other hand, the cost would be one-third of a farthing a pound, and by navigable canals (had we them all the way), one-sixth of a farthing.

On these differences in a great measure depends whether India is to become one of the greatest producing countries of raw material for the English market, and at the same time the best customer for our manufactures.[*]

The advantages of a cheap mode of conveyance in an agricultural country can hardly be over estimated; although we find that cotton from Sabarunpore, Jugadree, Kurnaul, Paniput, and even Delhi, is now carted to Ferozepore, at a loss to Government of Rs. 51-9-0 for every 100 maunds of cotton sent from Delhi to Ferozepore, while it would gain Rs. 5-6-9 if sent by rail to Calcutta. Thus the transport of every 100 maunds of cotton by this route, *via* Ferozepore, and the same weight of iron brought by the return carts is a dead loss to Government of upwards of 100 rupees, while 10 rupees might be gained thus—

Distance from Delhi to Ferozepore is 264 miles,

∵ 264 at 0-3-3½ = Rs. 51-9-0.

Distance from Delhi to Calcutta 1,000 miles,

$\frac{1000}{24}$ at 0-2-1 = Rs. 5-6-9.

From the above we arrive at the very remarkable conclusion, that it is cheaper for Government to send all the traffic by railway freight free, Government paying for the same, than to keep up metalled roads for its transport. Mr. Login was, it appears, not prepared for such a result when he commenced to collect his data, and it was not till he compiled these facts in the above form that he could believe in its correctness.

Having arrived at such a result, we can only come to the same conclusion as a reviewer of his pamphlet on "Roads, Railways, and Canals," did in a late number of the *Delhi Gazette*, where he said: "It is evident that light railways or tramways, as recommended by Sir Macdonald Stephenson, would be preferable to roads; these and all district roads that may be made should run at right angles to and not parallel with the great railways and canals. Thus they would act as feeders for the great lines of communication, and should be as numerous as possible."

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[*] The load here has been about doubled, owing to the *supposed* extra speed of dâk carriages.

The register of the 15th January shows that thirty carriages passed up and down the road on that day. Supposing that there were the full complement of seventeen horses at each stage, and also supposing the carriages proportionately divided, that each Dâk Carriage Company only despatched its proper share of carriages, thirteen out of the seventeen horses must have dragged a laden carriage twelve miles. Probably, however, some unfortunate animal had three trips. Could not the police send in a register of the number of horses at each stage kept up by each company, and the number of carriages that passed daily, only having the power to interfere when a horse had more than two trips in the twenty-four hours? Since writing the above, the Punjab Government has taken up the subject.

[†] Through the kindness of Mr. Henfrey, of the firm of Messrs. Brassey, Wythes, Henfrey, and Co., Mr. Login received the following information:—

The actual weight of stores carted by them was,—

During December, 1866, 80,000 maunds, or 2,857 tons.
„ January, 1867, 54,700 „ or 1,953½ „
„ February, 1867, 54,700 „ or 1,932 „

Total……… 6,742½

Average despatched from Delhi during December, 2,580 maunds daily; and in January and February, 1844, which for 51 days = 94 044. The other returns are obtained from as close an approximation as circumstances would permit of, and is probably not above two or three per cent. over or below the actual traffic.

2. By the above table it will be seen that the probable traffic as to dead weight and value would be as follows:—

| | By dead weight. | By value probably. |
|---|---|---|
| By road,… | 15 per cent. | 10 per cent. |
| By rail … | 25 „ | 50 „ |
| By canal… | 60 „ | 40 „ |
| Total…… | 100 „ | Total… 100 „ |

Excluding the grain trade, which is fluctuating, and as it is chiefly brought on camels does not injure the road, so may be omitted; and also leaving out the transport of salt, which averages at Delhi nearly 80 tons daily, and less than 3½ tons at Kurnaul, by the supplement of the Punjab Government Gazette, dated January 10th, 1887, at pages 9, 10, 11, and 12, we find that the average daily traffic over the bridge of boats at Delhi, to and fro, was as follows:—

| | |
|---|---|
| From May to October, 1865 ……………………………………………… | 123 tons daily. |
| „ „ „ 1866 ……………………………………………… | 118 „ |
| For January and February, 1867, average 151½ tons at Kurnaul. By the above return 7¾ tons has to be deducted for grain and 3½ for salt | 140½ „ |

Therefore 100 tons daily appears an ample allowance for the average traffic over the G. T. Road, after deducting the extra local traffic at Delhi and the Delhi Railway Stores.

[*] It would be interesting to trace at a number of points throughout India how the cost of wages, clothing, and food has been affected as the means of communication have been improved, The writer believes it will be found that the wages, as well as the quality of the food and clothing of the working classes have improved in somewhat the same ratio as roads, railways, and canals have extended. The prices of some descriptions of food have no doubt become much enhanced in some localities, but at the same time superior qualities of grain are grown. For example, Sawang, Cheenah, Mundooba, which formerly the lower classes used as food, is now disappearing; while Moongee (superior description of rice), &c., are taking their place; also the cultivation of sugar-cane, indigo, flax, cotton, opium, and other valuable produce has been much extended, which also no doubt tends to raise the price of grain, but at the same time to increase the profits of the cultivator.

Nay, in an economical point of view, it is also evident that Government can offer guarantees for the construction of such light railways as it has done for the main lines, with probably the same results, namely, with an ultimate profit, as is the case on the East Indian railway, which now returns 6 per cent. on outlay of capital, returning to Government a profit of ½ per cent. already, with a prospect of still larger returns.

The practical suggestions which may be arrived at are—

1*st.* That as the difference between the cost of transport on country roads by country carts is only Rs. 0-1-4 per 100 maunds per mile more than on metalled roads, kutcha roads unbridged may be made in the first instance, as suggested in a letter dated September, 1854, to the late Colonel Baird Smith by the author just before quitting the Ganges Canal for Burmah.

The cross section of the roads, he then recommended, should seldom exceed 18in. in height of embankment with no side ditches (see Fig. 3, Plate 348). The cultivator would thus only be one season deprived of a strip of land 80ft. broad, and afterwards of only 40ft.; while comparatively speaking, a passable road for at least eight months in the year would be available, instead of meandering tracks changing from year to year, as each cultivator blocks up the present cart tracks.

The cost of this first-class, or village road, would be probably 250 rupees a mile, and as each village should provide a public road through its lands, no compensation need be paid for the land. Any individual loss to cultivators should be paid by village funds, settled by Punchayet,* or by giving in compensation an equal area of land that is the common property of the village.

2*nd.* The second-class roads are what may be called "Pergunnah" (country) roads, also fair-weather roads, 50ft. wide, not metalled, and only bridged by small culverts, the larger streams crossed by causeways, or what are called "Irish bridges."

In the north-western provinces and the Punjab, probably the embankments will not exceed 18in, or 2ft. in height on an average, and will not cost more than about 1000 rupees a mile; compensation for the land required for such roads to be paid from district funds.

The general directions of these lines should be at right angles to the main lines of railways and canals; that is, they will cross the general drainage of the country, and should not be more than ten miles apart, depending on local circumstances.

As soon as the traffic sufficiently increases as to warrant making these fair-weather roads into metalled ones, the road should be raised so as to have no gradients exceeding 1ft. in 100ft., and metal 10ft. broad may be laid down, when these would become third class, or district roads, kept up at the expense of the district.

The expense of keeping up a metalled road being so great, country carts should be made to go along the foot of the embankments during the dry season of the year, and only permitted to pass over the embankment where the large streams are bridged. During the wet season and after a heavy fall of rain in the cold weather, when the earth would be easily cut up by carts passing over it, the carts should be allowed to pass over the metalled portion, but all other times this portion should be restricted for passenger traffic.

When this traffic goes on increasing, so that a tramway would probably pay, let one be laid down on the side of the embankment by private enterprise, keeping up the metalled portion portion as formerly, (see Fig. 4, Plate 348), and let a guarantee be granted by Government, as at present the public at home do not like to invest their capital without this.†

As the districts through which such lines run are chiefly benefited, the use of the embankment should be made over, free, to the Tramway Company, thus ensuring a larger return with equal advantages to the Government and the country. By this arrangement, also, the rails would be laid on old embankments, not on newly heaped-up earth, thus effecting a great saving in ballasting, while the experience gained as to the requisite waterway required for bridges would be most valuable; at the same time the line having existed for some years before, there would be a certain amount of traffic all ready; thus there would be the least possible delay in obtaining a return for the outlay of capital.

The advantages of a cheap mode of conveyance in an agricultural country can hardly be over estimated, and when we find that cotton from Saharunpore, Jugadree, Kurnaul, Paniput, and even Delhi is now carted to Ferozepore to be boated down the Indus, rather than sending it by rail to Calcutta, it is self evident that in spite of the moderate charges on the East Indian Railway, a still lower rate is necessary to ensure the carrying of the whole of the cotton trade.

With regard to Bengal, and such parts of India where metal is not available, the above arguments apply still more strongly as to the necessity for light railways; for, in a country where fuel is scarce, to use burnt clay as metal cannot cost less than probably double the outlay on kunker.

This leads us back to what Mr. Login recommended in 1858, while in charge of the Ganges and Darjeeling road, and we believe it is not too late yet to carry an embankment from Dingrat Ghât on the Mahanuddee, where the road branches off towards Purneah, and instead of following that line, to run the embankment along the left bank of the Mahanuddee to opposite Maldah, and then by running parallel to a branch from the Ganges which joins the Mahanuddee just above Maldah, all cross drainage can be avoided, with the exception of crossing the Mahanuddee itself at a point where the river has firm banks and a narrow deep channel; thus the left bank of the Ganges may be reached opposite and near to Rajmahal. Then by running the embankment at a sharp angle like a "redan" for a few miles down-stream, parallel to the main river, and half a mile or so away back from it, there will be always some point along these few miles which will have deep water along the left bank as well as the right one, so that steamers could always approach to within half a mile of the rail on either side. There would be also this advantage, that it would protect a large tract of rich land from injurious inundation. (See Fig. 2, Plate 348).

With this arrangement Mr. Login believes the Ganges can be crossed in less than one-half the time, and with far less inconvenience than at Carogolah Ghât, on the left bank of the Ganges, higher up.

The present embankment from Dingra Ghât on the Mahanuddee to Purneah, should be extended eastward and westward from west of the Gogra to the Burhampooter, leaving gaps in the encampment for the cross drainage. This embankment would connect Rungpore, Dinajepore, Purneah, Darbunga, Mozufferpoor and Azimgur beyond the Gogra, and ultimately join the proposed Rohilkund and Oude line of rail, which will be extended to Benares. By a similar line, some 30 miles north of it, Lucknow, Fyzabad, Oude, Goruckpoor, Bettiah, Nathpoor, Nawabgunge, and so on to the Burhampooter would form one continuous road, skirting the whole of our northern frontier; also, if considered necessary, embankments might be carried along the left bank of the Ganges, which would form levees or bunds that could be so constructed as to prevent much of the injurious effects of the inundation from the Ganges, and the rivers which fall into it taking place (see Fig. 1, Plate 348), while at the same time these embankments would form capital roads, as has been found to be the case not only in America, but also on the Irrawaddy, in that fast rising province of Pegu.*

Having thus briefly sketched out what Mr. Login's views have been for several years back, he considers that though each set of these embankments may be 500 miles in length, yet their cost would not probably much exceed one rupee per running foot of embankment; and after adding all possible charges could not be more than Rs. 7,500 a mile; or for the two main lines, 75 laks of rupees; while the cost of these along the banks of the Ganges would all probably be recovered by the land saved from inundation.* It may also be remarked that considerable portions of these lines connecting the chief towns are already made, so that the probable expenditure would not exceed half a million pounds sterling, to be expended over several years; that extending beyond Dinajepore being left to the last These portions are important also, as they would open out the waste lands of Assam to the thicky inhabited districts of Northern Bengal.

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* Native arbitrators.

† Should a still further of traffic necessitate a double line, it can be laid on the metalled portion.

* The above is no new idea, but simply an extension of what our Mahommedan predecessors, more than two centuries ago, carried out partially, and the embankments now, from want of care, have been allowed to get out of repair. These old Mahommedan-made embankments still exist at many points, and it was on the slopes of one of them near Purneah, that Sir George Yule, with a small body of Europeans, received and beat back the charges of the 3rd Irregular Cavalry, during the mutiny in 1857.

These embankments, though not bridged, would still act as feeders to the lines of railway which would run from the Ganges between the several rivers which drain Nepaul and Northern Bengal (see Sketch Map of Bengal, Plate 348); and when the traffic so increases as to warrant any portions being bridged, this can be done by local funds, as in every case it would be a local advantage, till then the inhabitants of these parts would have during the rains what may be called an amphibious mode of locomotion. Thus, the whole tract would be placed beyond the possibility of famine, by these internal means of communication, which would be passable at all seasons.

With respect to the navigable canals suggested by Mr. Login, he states from his experience of the country and its inhabitants, it is his firm belief that the returns from them would be half as much more than from the railways.

It is more difficult to give reasons for arriving at such a conclusion, than proving by figures, obtained from known data, that railways are more beneficial than roads; but when we know that in America its prosperity is in a great measure due to internal navigation, and one hears such favourable reports from Madras, we can naturally expect the same beneficial effects.

Regarding the embankments that have been suggested for northern Bengal, it would hardly appear necessary that private enterprise should be called in to aid in this work, as it is more a case between landlord and tenant, than of a mercantile nature. The expenditure on these works might be treated somewhat like "Tuckavee" advances—that is, the supreme Government might raise a loan to execute the work, and call on the local Government to recover the whole outlay from the several districts benefited, within some given period of years. Thus a system of embanked roads could be set about without delay; and when once these improvements have been carried out, the parties benefited would be then better able to pay back what Government had advanced.

That these embankments would be of the greatest advantage there can be little doubt, as is very satisfactorily shown by Mr. Fennessy's interesting report on embankments, now being constructed from Akouktoung, at the head of the Delta of the Irrawaddy to Pouabew, with the chief engineer's accompanying report.

From the latter we obtain the following information, which goes far to substantiate Mr. Login's views as to the benefits likely to be derived from a system of embankments in northern Bengal, as recommended by him.

By paragraph 20 of the chief engineer's report, it is shown that with an outlay of 15 laks of rupees, 350,000 acres of land will be protected and brought under cultivation, which, at 1s. 8d. per acre, as direct returns for land rent, amounts to Rs. 525,000 yearly. From this, Rs. 30,000 is deducted for annual repairs, leaving a clear return of Rs. 495,000 or 30 per cent. on outlay of capital.

The peculiar advantages for protecting and reclaiming land at the head of the Delta of the Irrawaddy may probably not exist in northern Bengal, but if even half or one-quarter as favourable results can be obtained, there is every reason why the inundated land in the valley of the Ganges should be reclaimed. That there is every reason for hoping so there can be little doubt, for the simple reason that earth-work in northern Bengal can be done at half or even one-third of the rates paid in Burmah, while the actual value of land in Bengal is much greater than in Pegu.

Even in this thinly populated province of British Burmah, we find by Mr. Fennessy's report, that the Burmese fully appreciate the value of the land reclaimed, as at one part he says:—"I am informed by the Deputy Commissioner that even now (May, 1863, before the work had been commenced) the people are fighting about the land, setting up their landmarks, and burning or cutting away jungle:" and again in his report, dated November, 1865, he says:—"From the energy with which the cultivators worked last season, there is no doubt that, in a few years hence, these extensive tracts of poisonous jungle and marsh, hitherto the refuge of wild animals and dacoits, will become one vast plain of rice cultivation, inhabited by a prosperous population." And still further on, he says:—"Indeed they are now, at many places, along the proposed line of works, reviving old claims (dating 20 or 25 years back) to certain tracts which, though at present growing nothing but jungle, were at one time hereditary estates, and abandoned in consequence of the encroachments of the river."

If such be the effect where there is not one-tenth the population which we have in Bengal per square mile, how much more will the reclaimed land be valued along the banks of the Ganges and its tributaries? This reclamation is not, however, confined to northern Bengal, but will extend to Assam, and when once a land communication is opened out, connecting the thickly populated districts of Dinajepore, Maldah, Purneah, with the rich but waste plains along the valley of the Burhampootra, we shall hear no more of complaints of want of labour among the Assam tea planters.

It appears hardly necessary to dwell longer on the advantages of banking off the inundation water, but they may be summed up under the following heads:—

1st. Additional area of land reclaimed.

2nd. Protection of this land from injury.

3rd. Power of controlling the quantity of water required for irrigation.

4th. Improvement of climate.

5th. Means of communication afforded by these embankments at all seasons.

Lastly. Not only increase of revenue to the state, but the security given by these embankments against failure of crops, and loss of revenue consequent thereon.

In conclusion, it is to be hoped that the information given regarding the comparative cost of transport over roads, railways, and canals, with the facts which have been collected on this important subject, will tend to the material welfare of India, one of the richest countries in the world, which an all-wise Providence has entrusted to the care of a Christian Government.

## THE ABRADING AND TRANSPORTING POWER OF WATER.

*(Continued from page 153).*

With Reference to Irrigation in India.

*(Illustrated by Plate 350.)*

Probably in no class of engineering works is a correct knowledge of the abrading and transporting power of water more essential than in designing irrigation canals, which in many countries, and especially in India, have already attained the proportions of a moderate sized river. Thus Mr. Beardmore, speaking of the Ganges Canal, during the discussion last year, at the Institution of Civil Engineers, on irrigation in India, said "it should rather be called the new Ganges high level river, as its volume was about equal to that of the River Thames, at Kingston, when flooded about two or three feet above summer level."

As the report of Proceedings of the Institution of Civil Engineers for 1867-68 has now appeared, we are enabled to give more extended quotations from Mr. Login's paper upon this subject, which has been published in a separate form in conjunction with the papers of Mr. Wilson and Mr. Higgin, under the able editorship of Mr. James Forrest, the secretary to the Institution. Mr. Login states:—

"That the power of water to hold matter in suspension is directly as the velocity, and inversely as the depth. He also suggests that water in motion rolls rather than slides, and that it is owing to this rotary motion, that water has the power to hold matter in suspension. Further, that with given velocities and defined depths, only a certain quantity of matter can be held in suspension, whatever may be the character of the bed and banks of the river or canal. If the velocity be increased, and the depth remain constant, scour will take place. If the velocity be decreased, and the depth is the same, there will be deposit. To such an extent is this the case, that at velocities sufficient with pure water to carry along large stones, a sandy or clay bed would be left undisturbed when once the water had got its proper load of silt, thereby indicating that in every case nature has adapted the channel to the circumstances. It has, however, to be borne in mind, that the real bed in many cases may be considerably below the apparent one after floods, and this must be provided for. Instances could be adduced in illustration of these views.

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* Taking the value of an acre at only Rs. 20, if only half a mile of land was reclaimed the outlay on these embankments would be recovered; while probably a strip five miles broad would be saved from inundation, thereby improving the climate also.

With reference to the best slopes for canals, and how the slopes are to be regulated, it is essential, in the first place, to ascertain what is the slope of the river, when not in flood, from which a supply is to be drawn off, under circumstances similar to those of the canal to be constructed—that is, as to depth and soil; and then to make a small allowance for the tortuous course of the natural river. By neglecting these indications of nature, and acting on preconceived notions, errors are likely to arise. For example, much has been said about the excessive slope of the Ganges Canal; but the experience gained during the last five years has shown that, with velocities which with pure water would most certainly have scooped out the bed, there has been a steady silting up of the bed. (Plate 350, Fig. 2. Section of the Ganges Canal at Roorkee). This is owing to the nature of the water admitted into the canal, which from October to March is nearly pure; but as soon as the snow begins to melt in April, the water is highly loaded with silt. This is carried down the canal in the hot season, and is deposited over the canal bed, to be again picked up and carried forward in the cold season, when the water becomes more pure. The slope—that is the velocity, or in other words, the abrading and transporting power to be given—should be such that the deposits should be balanced by the abrasion. Experience on the Ganges Canal has shown that this requires a mean velocity of about 3¾ft. a second, with a surface slope a little less than 14in. in the mile. This slope and velocity might be modified by admitting more water into the canal during the six hot weather months, when the slope would have to be increased; or should the hot weather supply be diminished, the slope would have to be decreased. Under such circumstances, it is evident that vegetation cannot exist in the main canal where the bed is never constant; and in the minor channels the clearance of weeds is a matter of no great difficulty. The experience thus gained is also important in its bearing on the question of navigation. In the course of a previous discussion at this institution, on the employment of steam power on canals, it was proved that velocities exceeding 3½ miles an hour caused a wave of translation which would injure the banks. Now, as it is requisite to have a mean velocity of 2½ miles an hour for the Ganges canal, it follows that, in forcing a boat up against the stream only 3½ miles an hour, a speed of only 1 mile an hour could be attained, and that any attempt at quicker velocities would injure the banks; so that, irrespective of the loss of power in stemming a stream running at 2½ miles an hour, the banks could not stand if there was quick navigation. Hence it would appear, that an almost still-water canal is required for navigation, in addition to the present canal, which however may be used for down-country traffic.

"With reference to the mode of regulating the slope of canals, it is proposed to refer to some suggestions on the construction of canal falls. One of the greatest problems for the canal engineer is the best method of dealing with the excessive slope of the country through which an artificial river has to flow. In nature this is provided as follows:—First, by waterfalls, which abound in all hilly countries. Secondly, by barriers of rock, stretching like weirs across the channel of the river, also met with among the hills. Thirdly, by rapids formed of boulders that have been carried down the river, and thus create what may be called temporary weirs or barriers. And lastly, where clay or sand exists, nature, by making the course of the stream tortuous, adds to the length of the river, thus practically reducing the slope, and, to a minor extent, the flow is also retarded by the sudden bends in the river, which tend to check the velocity and to increase the depth.

"The last plan appears to have been almost invariably adopted by engineers in former times; and in the present day it is still to be seen in Egypt. In India, also, several examples of the kind are to be found; and one of the largest and best-paying canals in Upper India—the Western Jumna Canal—is constructed on this principle.

"When surveying the Rechna Doab, the author found indications of a like nature, with masonry escapes and sluices, but in no case did he discover any falls. Near Sealkote, Ali Murdan Khan, by adopting this tortuous, or rather zig-zag course along the top of a ridge, was able in a few miles to bring the canal from the high ground of the Bhangur into the low lands of the Khadur. The fall of the country was so great, that any attempt at a straight line, or even to follow the course of the small 'nullahs' on each side would certainly have led to a retrogression of levels. The best proof of the success of the measures then taken is to be found in the fact, that the remains still exist of the extensive gardens of Sodrah, which were irrigated by the water of this canal.

"It does not appear who was the first to introduce falls on canals in India. But the subject can only have been recently appreciated, as Lieutenant (now Colonel Sir) Proby T. Cautley had to build masonry falls to the Eastern Jumna Canal after it was opened. The experience then gained led to the adoption of the ogee form of fall (though several others were suggested) for the Ganges Canal. (See Figs. 8 & 9.)

"The change recommended by the author while the canal works were in progress, was to lower the flooring of the fall, so as to form a cistern to receive the descending water. (Figs. 4 & 5, Zig-zag Falls.) A French engineer also recommended to Sir Proby (then Major) Cautley, a series of broad steps; and in 1862-3 this was partially carried out by the author on all the falls in the first division of the Ganges Canal, by securing a framework of timber, 5ft in height, above the crown of the ogee, instead of trusting to sleepers, which were constantly giving way. (See Fig. 9, No. 2.) By this arrangement the water is held up to the level originally intended by the projector; and it is a remarkable fact that, though there is a perpendicular fall of 5ft. or more on the crown of the ogee, no injury has as yet been done to the brickwork at the point where the water impinges. Probably this is owing to the water which passes through the open spaces of the timber framework forming a cushion for the descending water.

"Where the deepening of the canal bed was excessive, owing to the increased velocity of the stream, prior to 1862, and the next set of falls was 11½ miles lower down the canal, back water could not be held on the flooring of the Mahmoodpoor falls. The brickwork here being inferior could not withstand the violent action it was exposed to, and hence the serious accidents to this work in 1862. (See Fig. 8 at A B; C D; E F.) But by throwing a submerged weir, 3½ft. high, across the chambers of the falls, a cistern was formed to receive the descending water, and the violent action was at once overcome. (See Fig. 9, No. 2 at B.) For the last five years, therefore, since these arrangements have been carried out, the canal bed has been gradually silting up, and little or no serious injury has resulted to the works, except to the Jowlee falls, the circumstances of which were similar to those of the Madmoodpoor falls. It is proper that these facts should be known, before other descriptions of falls are considered, as those on the ogee principal have been so generally condemned. Sir Proby T. Cautley in adopting this plan, in preference to others, feared the concussion and the tremor that might be caused to works resting on quicksands, which would probably loosen some of the bricks, and it is possible that this has happened in cases where the floorings rest on arches.

"The plan for overcoming the excessive slope of the country on the Barree Doab Canal is chiefly by perpendicular falls, the water being received into a cistern. Rapids have likewise been used where boulder stones were plentiful. In Madras perpendicular falls are also employed, but instead of the water falling into a cistern, it impinges on a flooring of ashlar work. As the slope of the deltas in Madras is comparatively little, falls are not so necessary, and as good building stone can be obtained at a moderate cost, a simpler description of fall is sufficient.

"A system of under sluices has been suggested by Colonel Fyfe. This was thought of for the Ganges Canal, but it was considered that nothing but cast-iron sluices could stand, and twenty-five years ago this was deemed impracticable, as there was not a smith in the country who could weld together two pieces of English iron. Mr. Parker has proposed to contract the water-way at the falls, so as to preserve a parallelism between the surface of the water and the bed, which has the great recommendation of cheapness.

"In the present day, the engineer has to avoid both injury to the land and to the climate, and instead of copying nature, by making the course of an artificial river tortuous, and permitting marshes to exist, an artificial river should be so designed that the least possible area of land may be injured, and the climate improved rather than rendered more unhealthy. The last of the four natural methods of operation previously adverted to must, therefore, be discarded, and some other plan adopted, the study of natural provisions being still kept in view, as forming the best guide.

"The first of the four mentioned relate to water-falls, but these only exist where hard rocks predominate. The third example, that of rapids, is found in all the rivers which drain the southern face of the Himalayas, which has already undergone the action of water. These actions are not permanent, but year after year the boulders of which they consist are rolled forward, grinding and abrading each other, till they ultimately become sand or mud. The action of the water over them is also excessive, which is overcome by lengthened slopes; consequently this plan can only be adopted where boulders can be procured in large quantities and at little cost. Hence it appears that, under most circumstances, recourse must be had to the second mode of overcoming excessive slopes; namely, barriers, or, as they are technically termed, "weirs." Belts of hard rock have been thrown up at certain distances across the course of some rivers in Southern India, which hold up the surface of the water at intervals with deep reaches between; and so deep are the reaches, and so slow the stream, that in some cases it is intended to make use of them for navigation, passing the barriers by locks. It is found, however, that above each barrier there is deep water where except during floods the surface of the water, comparatively speaking, is nearly horizontal, though when the river is at its highest, these barriers, or rapids, sometimes almost disappear, being only observable by a slight 'swirl' on the surface over the site of the obstruction, as in the case of the Madras anicuts. This is found to be the case with rapids on the rivers of Northern India; (See Fig. 3) and it is well known that it is quite possible to ford the Ganges in the dry season on an elephant, at the head of a rapid, but quite impossible to do so below one, owing to the great depth of water. In short the bed of the river is in no case parallel to the surface of the water, but in almost every instance slopes upwards from the foot of one rapid to the head of the one immediately below. Again, if these rapids, or fords, be examined, it will be found that they are never situated where the channel is contracted; and, instead of crossing the stream at right angles, they are generally oblique to it, and on other occasions curve downwards to the stream. It is evident that nature adopts this peculiarity, on purpose to extend the length of the rapid, and thus reduce the action. In England, from the time that water has been used as a motive power, mill dams and weirs are found to be situated in the broadest reaches of the rivers, and generally oblique to their course.

"It is remarkable that where weirs are thrown across the bed of a river, they do not appear to raise the bed to any great extent on the up stream side; and instances have been known where it was difficult to raise laden boats sunk above weirs, but no sooner did a flood pass down, than the boat was lifted out of the deep water, and carried over the weir—thus showing an action on the bed of the up stream side to a considerable depth. With examples like these, it is evidently impossible to attempt to hold up the bed of an artificial river by bars or bridge-floorings, and any endeavour to do so only causes a disturbance in the flow of the stream. On the Ganges Canal, when first opened, and until sleepers were put in the grooves above the falls, deep holes were scooped out of the bed, on the up stream side. At the first fall, at Ranecpoor, this occurred to a dangerous extent, as at one point the hole was upwards of 20ft. deep.

"In nature the slope of the surface of a river is never constant, but varying according to the volume discharged. It is always greatest during floods, and this holds good in the plains, as well as among the hills. In dry weather the stream never keeps the centre channel, but changes from side to side, thus adding still more to the length and reducing the slope. It has been supposed that stiff clay will prevent the abrasion of the bed; but this appears to be an error, for the stiffest clay will be cut through in time, if the velocity of the current be too great. In Robison's "Mechanical Philosophy," it is stated, "that a velocity of 3in. per second at the bottom will just begin to work upon fine clay fit for pottery, and, however firm and compact it may be it will tear it up. . . . A velocity of 6in. will lift fine sand; 8in. will lift sand as coarse as linseed; 12in. will sweep along fine gravel; 24in. will roll along rounded pebbles and inch diameter; and it requires 3ft. per second at the bottom to sweep along shivery angular stones of the size of an egg.' In practice, however, it is found to be different, and deposits take place with velocities far in excess of this. The author has found in Upper India, that three times the velocity is required to hold in suspension the earthy matter admitted into canals from turbid rivers that would be sufficient to disturb and roll along the same description of matter over the bed if the water was pure. A clay bed is no doubt a great advantage, as it prevents absorption, and on this account it should not be cut through if possible.

"It is now proposed to describe a new description of fall, recommended by the author for the Recbna Irrigation Works, which appears to meet most of the difficulties alluded to. Before doing so, however, a table is given below, showing, approximately, the sections and slopes best adapted for irrigation canals and water courses in Northern India.

"The experience gained on the Ganges Canal tends to prove that both the depth and the slope may be increased. A Committee lately recommended a reduction of about 1in. per mile, less than that intended by Sir Proby Cautley; thus showing that the flow of water is retarded considerably, by having a load of earthy matter to transport.

"With the quantity of silt carried down by the canals in Northern India, if 10 per cent. be added to the slope given in the table, probably a close approximation to the actual state of matters will be arrived at, with a corresponding reduction of the widths and increase to the depths of the channel. From the table it will be seen that the best slope for a canal in Upper India, discharging 5,000ft. per second, is about 13¾in., or 1·15ft. in the mile. Taking the Ganges Canal as an example, it is found that the flooring of the regulator at the head is 133ft. above the canal bed at the end of the 50th mile, and 217ft. at the end of the 100th mile. Therefore the general slope of the country in the first 50 miles is 2·66ft. per mile, and in the second 50 miles 1·68ft. per mile. In the first 50 miles, therefore, the excessive fall would be 75½ft., and in the second 50 miles 26½ft. In the first instance, with steps of only 5ft. each, 15 falls would be required, or, on an average, one fall at every 3⅓ miles; or, in other words, no road bridges would probably be required along these first 50 miles, except for one or two high roads. Again, along the next 50 miles only ten road bridges and five falls would be necessary; or, in all, 20 falls and 10 bridges. Along the first 100 miles of the Ganges Canal there are three regulating bridges, 30 road bridges, and 11 falls with bridges—in all 44 bridges. Leaving the regulating bridges out of consideration (as probably necessary under any circumstances), still there would be a saving of 10 bridges in the 100 miles.

"Supposing the proposed 'zig-zag' falls to cost only one-half less than those on the Ganges Canal, and double the price of road bridges, or say £4,000 each, there would be—

Thirty road bridges at £2,000 each = £60,000
Eleven falls ......... at £8,000 each = £88,000
Total......................£148,000

Against ten road bridges at £2,000 each = £20,000
And twenty zig-zag falls at £4,000 each = £80,000
£100,000
Difference..................£48,000
Total .......................£148,000

or a saving of nearly one-third in masonry works for bridges and falls along

*Table showing approximately the Sections and Slopes probably best adapted for Irrigation Canals and Water Courses for Northern India.*

| Cubic Feet of Discharge per Second. | Calculated Sections. | | | | | Proposed Sections. | | | Side Slopes of Channels. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| | V. Mean Velocity in feet per Second. | H. Hydraulic Mean Depth. | Breadth of Channel at Bottom. | Depth of Water with full Supply. | Slope of Surface of Water in Inches per Mile. | Breadth in Feet at Bottom. | Depth in Feet with Full Supply. | Slope of Surface of Water in inches per Mile with Full Supply. | | |
| cubic feet. | feet. | feet. | feet. | feet. | inches. | | | | | |
| 50 | 2 | 2 | 2½ | 4 | 15 | 2 | 4½ | 16½ | 1 to 1 | Calculated on Beardmore's Formula.<br>$\frac{11\sqrt{H \times S}}{12} = V.$<br>Where H = Hydraulic depth in feet.<br>„ S = Fall in feet of surface of water per mile.<br>„ V = Mean velocity in feet per second.<br>In no case should the mean velocity exceed 4ft. per second, 3¾ probably being the safe limit, and not less than 2¾ft. for the main channels. Keeping in mind that the greater the velocity the cheaper the section in deep digging. |
| 100 | 2¼ | 2½ | 4½ | 4¾ | 14½ | 4 | 5¼ | 16 | 1 to 1 | |
| 250 | 2½ | 3⅓ | 15 | 5 | 13½ | 13½ | 5½ | 14⅚ | 1 to 1 | |
| 500 | 2¾ | 4¼ | 27½ | 5½ | 13 | 25 | 6 | 14⅓ | 1 to 1 | |
| 1,000 | 3 | 5 | 50 | 6 | 13 | 45 | 6⅔ | 14⅓ | 1 to 1 | |
| 2,000 | 3¼ | 6 | 77½ | 7 | 13 | 70 | 7¾ | 14⅓ | 1½ to 1 | |
| 3,000 | 3½ | 7 | 95 | 8 | 12¾ | 85 | 8⅘ | 14 | 1½ to 1 | |
| 4,000 | 3½ | 7½ | 121½ | 8½ | 12¾ | 110 | 9⅓ | 14 | 1½ to 1 | |
| 5,000 | 3⅔ | 7⅔ | 147½ | 8½ | 12½ | 130 | 9⅓ | 13¾ | 1½ to 1 | |
| 6,000 | 3¾ | 8 | 170 | 8¾ | 12½ | 150 | 9⅔ | 13¾ | 1½ to 1 | |

the first 100 miles; or, in other words, the cost would be considerably under, rather than over, the present plan.

"Again, by making use of falls of 5ft. instead of 8ft. or 9ft., the saving in depth of digging would average less by one-half the difference of height of fall; and as by this 'zig-zag' fall system the breadth at the falls requires little or no increase on the present plan a considerable saving in earthwork would be effected.

"The next question to be determined is, whether the falls are likely to stand the action of the water. It is proposed that the length of the lip should be so extended that only 10 cubic feet a second shall pass over each foot, which with a full supply will require a height of water of about 2ft. Now it has been already shown, that no injury has as yet occurred to the Ganges Canal with two and a half times the volume descending an equal height on brickwork. It is apprehended that there can be little danger where there is a cistern to receive the water; and it is also evident that, as this height of fall increases, the volume of water diminishes, so that there can be little doubt of the work standing, even if only brickwork be used.

"With reference to the utility of the falls, it has been shown that, on the up-stream side of a weir, there is an action on the bed, and examples have been given in proof of this. Above all the falls on the Ganges Canal the bed is found to be 1ft. or more deeper than it was originally excavated, though the water is held up 5ft. by a framework of timber.* The water in the canal, with a full supply, may, therefore, be considered to be as deep immediately above the weir as at any point higher up; so that when the whole volume is passing down, the depth will be 9½ft. throughout.

"Should the falls be only 3½ miles apart, there would be 3½ft. of water at the down-stream side of every fall, and 7½ft. on the up-stream side; or the canal could on any occasion be closed, and yet contain one-half of a full supply in such reaches as did not require repairs. Thus, if necessary, the injured works might be repaired, and both above and below such points navigation and partial irrigation might be maintained during the time that the canal was closed."

We cannot enter into the question of the distribution of water where Mr. Login shows that, by the adoption of this peculiar description of zig-zag fall, an almost uniform discharge can be secured, so that the water may be sold by volume of discharge, which is one of the great desiderata in irrigation, but will conclude our quotations with that portion which includes a description of the several illustrations given in Plate 351:—

"Plate 350, Figs. 2 & 9, will assist to show at what excessive slopes the canal was running, prior to the time when the author held up the water above all the falls in November, 1862. The expedient for protecting the falls, recommended in November, 1861, was intended to make use of such materials as were available for the purpose. No. 2 shows (at A) what was carried out a year later, under pressure of trying circumstances, such as appeared to justify anticipation of official sanction; and the author ventures to submit, that this simple framework has mainly contributed to the saving of the Ganges Canal from destruction. It represents (also at B) the arrangements for holding back water on the flooring of the Mahmoodpoor falls, which were officially sanctioned in January, 1863, and then carried out. This work was found in October, 1867, to be still in perfect order. No. 3 shows (at C) the change that was introduced in August, 1867, by removing the framework of timber that had been erected five years previously, in order to hold up the water above the falls, and substituting a brick wall protected by planking. In several parts the brick on edge was, however, being washed out at the point of greatest impact. With this exception the canal bed and the works appeared to be in a most satisfactory state, which cannot but be a matter of congratulation to all well wishers of India, who know that the lives of millions of human beings depend on this canal. Six years ago the author stood almost alone in maintaining the opinion, that the Ganges Canal needed only some protective work, and did not require the radical alterations then proposed. The author will only add the expression of his firm conviction, that the works may be placed out of danger, by the judicious use of wood and iron, at a less cost than if stone be employed, without depriving the country of the benefits of irrigation beyond a short time.

From these quotations, and by a reference to the diagrams given in Plate 350, but more particularly to those marked Figs. 2 & 6, it is evident that nature is the best judge of the proper velocity and slope required. If the natural rivers of northern India require slopes exceeding 1ft. in the mile, it can only cause delay and end in disappointment if we attempt to give the artificial rivers slopes of only one-third or one-half which the teachings of nature appear to show. To enable us to apply these readings that they may be adapted to the requirements of the various circumstances, to some of which we have made reference in the preceding papers during the last few months, a series of practical experiments on a proper scale should be undertaken.

As, however, the subject is one of national rather than of limited importance; and, moreover, as the cost would be too considerable to be undertaken by private individuals, such experiments should, we think, be conducted for the national advantage at the cost of the Imperial treasury.

## THE FAIRLIE STEAM CARRIAGE.

On the 15th ult. we had the pleasure of witnessing a very interesting trial at the Hatcham Ironworks, of the combined engine and carriage designed by Mr. Fairlie. It is intended to run on a Metropolitan Railway, and as it was necessary, in consequence of the confined space at the terminal stations, that its dimensions should be such as to admit of it being turned on an ordinary 40ft. turntable, the dimensions are somewhat less than that recommended by Mr. Fairlie for ordinary cases. It will consequently accommodate only 66 passengers, instead of 100, as recommended.

The chief peculiarity of this steam carriage, is in the disposition of the wheels, which consist of two four-wheeled trucks or bogies, which support each end of the carriage. Upon the foremost bogie, the wheels of which are 4ft. in diameter, is placed the engine which is connected to the carriage proper by means of a strap which encircles the base of the upright boiler; the forward end of the carriage resting upon the carrier frame. The other end of the carriage rests upon a bogie provided with four ordinary carrying wheels, 3ft. 6in. in diameter. Thus, although the total wheel base is apparently very long, the actual wheel base which has to be considered when estimating its capability of passing round curves, is only 6ft., the length of the wheel base of each bogie. In the experiments in question the steam carriage travelled round a line laid in a garden adjoining the engine shop at Hatcham, with the greatest facility, although the curves were only 50ft. radius, and the rails roughly laid.

The following are some particulars of a carriage proposed by Mr. Fairlie for ordinary branch lines:—

Cylinders, 8in. diameter; stroke, 12in.; coupled driving wheels, 4ft. diameter. Steam pressure in boiler, 150lbs. Effective pressure on pistons, 100lbs. per square inch. Tractive power, 1,600lbs. Diameter of trailing bogie wheels, 30in. Extreme wheel base, 57ft. Clear width of carriage inside, 8ft. Total weight of steam carriage, with fuel and water for a 40 miles run, 14 tons. Accommodation for 90 passengers weighing 6 tons. The steam bogie carriage has ample power to take one additional light carriage, specially constructed to accommodate 100 passengers, or two light carriages with 50 passengers in each, at an average speed of 30 miles per hour, up gradients not exceeding 1 in 60, and with a consumption of coke less than one-third of the ordinary passenger locomotives now in use. The maximum weight on the driving wheels is reduced to 2½ tons per wheel, instead of 5 to 8 tons on a wheel as now ordinarily in use, thus effecting great economy in the maintenance of way, and wear and tear of rails. From the extreme length of wheel base, the steam carriage will be remarkably steady at high speeds when running in the straight line; and by the arrangement of the double bogie can pass round curves of the smallest radii now in use with great precision and steadiness, and at the termini can be turned slowly on a semicircle of 60ft. in diameter. For the purpose of repairs, auxiliary or supplementary wheels are provided at the end of the carriage nearest the engine, which may be lowered on to the rails when the steam bogie is detached from the carriage, which can be done in a few minutes. The guard's compartment being next the engine, the guard and engine-driver are in close communication, and a platform with hand-rail round the sides of the carriage, or, in the case of saloon carriages, a passage down the middle, is provided to enable the former to communicate with the passengers when necessary is in motion.

## PATENT LAW.

### The Bovill Litigation.

(*Continued from page* 151.)

The evidence, together with the addresses of the counsel in this trial, would take up too much space to be reproduced here, but those of our readers who desire to peruse the whole case can obtain from Messrs. Bradshaw and Blacklock a volume containing an account of the entire trial. The summing up of Mr. Justice Willes is very important, and we give it *in extenso*.

"Gentlemen of the jury, this is an action brought by George H. Bovill, who is an engineer, against James Goodier, who is a miller. It is an action, however, of a peculiar kind; because it is simply brought for the purpose of trying a question which had appeared to the Master of the Rolls, in another proceeding, to be fit to be tried before a jury; and that learned and eminent person thought it was better to send it to be tried in another court than to summon a jury before himself—no doubt wishing to have entirely fresh minds brought to bear upon the question which he has sent for your consideration. He was also willing that the judge should be newly introduced into the case, as well as the jury, very likely thinking that the judge would be the chief justice, whose removal from this court we all have reason to deplore, and whose experiences in cases of this description was so very great. However, the task has fallen upon me, and I must discharge it as I best can. Whatever opinions I may lay down, in point of law, are the result of my best attention to the case, and will be binding for the purpose of the present day; and whatever intimation I may have given, if I have given any, or shall give any, in the course of the summing-up, on a question of fact, is entirely open to criticism and review by you; because you are the exclusives judges of facts. If I should express anything which may appear to be an anticipation of your verdict, or an opinion one way or the other upon a question of fact, it would be simply from my desire to use compendious language, because if I thought it was the best way of proceeding, and would not rather weary than enlighten, I should prefer simply reading the questions, reading over my note of the evidence from beginning to end, and leaving the matter to you without remark. I am satisfied, however, that that would only be doing over again what, during the course of so many days, has been going on during the present week,—repeating a process which has had probably its effect—it may be its full and complete effect—upon your minds, and I shall therefore abstain from doing so, and shall endeavour to present the case to you in as short and clear a form as I can.

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* This framework of timber has irregular open spaces, through which some water passes, and probably when the volume of water is very small, this prevents any silting up on their up-stream side. A system of iron sluices might be arranged, to produce a similar effect, but to be self acting, so as to be opened with an increased supply, and thus reduce to a certain extent the variation of the head of water passing over the lip, while at the same time affording the means of laying the bed dry when necessary.

"I will first tell you what is the law with respect to such novelty as is sufficient to sustain a patent; and, having done so, tell you what is the construction that is to be put upon the specification of Mr. Bovill's patent of 1849, in determining the question whether that patent was anticipated, either in the documents which have been produced and submitted to your inspection, or by the practice spoken of by any of the witnesses who have been called. In dealing with the latter evidence especially, I shall endeavour rather to classify it, to present to you what appears to me, subject, to your better judgments, the results of the evidence of the witnesses, rather than to detain your by reading over again everything that the witnesses have stated. I need hardly tell you, gentlemen, that a patent is a grant for the exclusive right to do something for a certain term; and the power of making such a grant is allowed to the Crown, but it is restrained within certain limits. The Crown cannot grant a patent to anybody unless these conditions are complied with. It must be a thing which is practically useful in the business of life. There can be no patent for a mere idea, however splendid may be the genius which suggested it. A patent can only be granted for some idea which is given to the world, and which can be applied so as to produce a useful result, which is called in the statute "some sort of new manufacture." Passing that by, I may tell you that if this patent is what it professes to be, it does contain such elements of utility as would fulfil that condition. I will say no more. It must be assumed as certain that it does. A long investigation has taken place before the Master of the Rolls upon the subject; and that learned judge, if he had thought there was any doubt as to utility which he wished to have solved, would no doubt have sent that matter for your consideration. With great deference to some strong remarks of the learned counsel for the defendant, which I do not wish to touch upon at any length, when the first judge before whom a question comes arrives at a conclusion satisfactory to his mind in the affirmative of that question for one party or the other, it is not unfair, but it is most just and proper, that he should decide that at once, so that the parties, instead of litigating for a lifetime,—or the litigation may last for an age, and a lifetime comes far within these limits,—a decision should at once be made. That is decided. Secondly, it is necessary there should be novelty in the invention; and as novelty must consist in the discovery of some improvement—I will say in manufactures for this purpose, for I do not mean to deliver a treatise upon the Patent Laws, a suggestion of something beneficial that can be done in the arts, either a discovery of some entirely new process, or a discovery of a mode of improving a process which was previously known. A mere idea or principle I have already excluded, and therefore I need not exclude it again in speaking of novelty. It must be new in this sense that the man who gives it to the world, and who claims the use of it to himself, or those to whom he sells it by way of absolute sale or license—a patentee in a word—should have added something to the sum of knowledge in the way of principle and of idea, and should also have given some new process, or some improvement upon an old process, by which that principle is worked out to a beneficial result. Thirdly, there must be an infringement. With respect to that I make the same remarks that I did with reference to utility. What Mr. Goodier has done—not that which is completely indicated, or to be taken as completely indicated, by the models produced, but that which it is proved he had done, although those models, so far as they go, suggest a different arrangement from the patent of Mr. Bovill of 1849—must be taken into consideration in determining the limits of that patent. The infringement, so far as the infringement as a separate question is concerned, has been decided by the Master of the Rolls; and I beg leave to say—because it would be wrong that I should pass over what has been said with respect to the supposed inconsistency in the judgment of that eminent Judge—that there was no inconsistency at all in his directing an issue as to the novelty of Mr. Bovill's patent, and in directing no issue as to the infringement of Mr. Goodier; and at the same time saying, that the arrangements of Mr. Goodier might be referred to by the counsel for the defendant for the purpose of showing the jury what was the extent of Mr. Bovill's patent in the sense in which he understood it; and for this reason, because, when I come to observe upon Mr. Bovill's patent by-and-by, I shall take occasion to say, as Mr. Nasmyth did on the first or second day of the case during the plaintiff's evidence, that all the elements of Mr. Bovill's patent are old, that all the elements of that which was produced as done by Mr Goodier's are old, except in arrangement, and that the question whether Mr. Goodier's arrangement is an infringement of Mr. Bovill's patent depends upon its action, and depends upon the question whether that action produced the result of the new and useful application which Mr. Bovill says he has hit upon in his patent of 1849. I think you will at once see that the two are not inconsistent, but perfectly reconcilable and just; the learned judge who sent the issue being satisfied that in working Mr. Goodier's contrivance he did do that which Mr. Bovill has pointed out the means of doing in his patent of 1849, and did do it under conditions in which it was an infringement,—namely, by regulating the extent to which air was drawn off by means similar to, or in imitation of, Mr. Bovill's. And here I will add but one word more,—that which is an infringement of a patent is not necessarily the exact patent process itself. You seldom find an infringer who is clumsy enough, and barefaced enough, to put up the exact thing which he finds in the plan annexed to the patent. He puts up something which is somewhat different in form; but if he puts it up so as to work in the same way and to arrive at the same result by the application substantially, no matter in what form, of the principle which is pointed out by the patent, he infringes the patent. It may be he has, in his endeavour to conceal his infringement, introduced parts which would only be introduced in a direct copy of the patent, and it may be he imperfectly gets at the result, though he does get at the result contemplated by the patent and by the same means. That is a simple explanation of why it is that we are trying the novelty, and not the imitation, and without any of those tremendous results which one would suppose were pointed out to you if the object of this proceeding were to endeavour to indue you to do something that should interrupt or defeat the course of justice instead of assisting in arriving at the truth. With respect to that of Mr. Goodier, as I have introduced it, I am bound to say this, that if I had not agreed, upon consideration, with the judgment of the Master of the Rolls, that Mr. Goodier's process, if so worked as to exhaust the plenum, as it has been called—an unfortunate expression, but still intelligible enough, I should think—I can entertain no doubt that it was an infringement of the specification, read as I should have read it myself in the first instance, because, as to Mr. Goodier's plan, where he annexed the trunk a little way down, or some way down the meal-spout—I should think, if that worked on the mill-case so as to exhaust the plenum with the regulated machinery said to be pointed out in Mr. Bovill's patent of 1849, it would be an imitation of Mr. Bovill's plan, though it would not work just at the same place, at the top of the mill-case. With respect to the other, instead of putting the fan above, the fan is put below,—it lets the meal go down, and it drives the air up through that pipe into that chamber of which you saw a representation. With respect to that, I think say also, with great humility, had I decided for the first time, I think that is a clear imitation of Mr. Bovill's patent, notwithstanding the difference. I cannot perceive any difference in the action between that and Mr. Bovill's patent if it be worked so as to exhaust the plenum, and the plenum only worked in the regulated way, whether the fan is at the bottom or at the top, or at the side, if the fan has the effect of blowing and sucking,—I should add blowing or sucking the air in the space between the mill-stone and the side of the case, to the extent that Mr. Bovill says he has discovered it to be beneficial, that the wind should be removed, and sucking that finally, though not in the first instance, up the spout above the mill-case into a receptacle above,—it was necessary I should say that, lest, by not saying so, there should be any doubt entertained that I humbly concur in the judgment of the Master of the Rolls upon that subject.

"Now, in this case, as I have said, I have eliminated for the present the usefulness, and I have eliminated the bare question of infringement, and explained why it was you were allowed to look at Mr. Goodier's plan of doing what has been decided is the thing which Mr. Bovill has done by his patent of 1849. The reduction of some idea to practice, the attainment of some useful object, the pointing out of something previouly ascertained, without which the purpose was not effectually attained—these are all forms of language which might be referred to—into a process by which you get at once at the most desirable result, suggesting an idea and giving the means of carrying that idea into effect, I believe all those forms might be used. I do not differ from either of the learned counsel in the view which either of them has pointed out, that if something remains to be ascertained before the process can be practically applied to a useful purpose, the person who discovers that something, and shows how to do it, may take out a patent. Now I have completed my general remarks, I omit the illustration, because I think I ought to husband time, and spare your strength at this period of the day;—I have endeavoured to put that clearly, and I leave it.

"Now, then, I come to the questions. Mr. Bovill's patent claims, as you know, three thigs:—First of all, putting holes in the stones as described, with reference to plate A, which you have had so long before you. Then there is the exhaust process used with the blast; and then there is the shifting, if I may so say,—the chamber of 'porous fabric,' as perhaps I had better call it, to put it shortly. You are asked with respect to each of them four questions,—whether it was new at the time of the patent, or whether it had been anticipated in the sense which I have endeavoured to explain? Then, if it had been anticipated, whether there had been a prior use in the sense that somebody had found out the way of doing the thing, so that he could do it before Mr. Bovill took out his patent of 1849; not merely whether he had the idea in his head, or set about experimenting upon it. In dealing with that question, I must remind you that the first relates to millstones with holes. There had been millstones with holes before the patent; but it relates to holes being used in the top stone when it is fixed. The top stone had been fixed before; holes had been used in millstones before; but holes had not been used in a top stone when it was fixed before. The evidence with regard to that part of the case, as to the first question, turning upon that, I believe,—and I have endeavoured to ascertain it from reading my notes,—consists of what I have already stated; it consists of the direction in the Scotch specification of 1846, and of Mr. Bovill's evidence and Mr Nasmyth's evidence for Mr. Bovill. The Scotch patent you heard read by both the learned counsel; and you heard it observed upon. It is pointed out in general terms that holes had been beneficially introduced into stones; and the plate showing a stone with the hat round the eye was submitted to you. It is suggested on the part of the plaintiff, that anybody would at once see that the holes must come from the centre of the stone, or they must come from somewhere near the centre of the stone. Mr. Nasmyth was asked about it in the cross-examination; but what he said was, that that was a mere general direction given in the Scotch patent that holes would not do to be put in any place, but that the holes must be put in a prope place, and with proper directions. He said that the arrangement which was suggested in the patent of 1849 was a convenient arrangement. I believe Mr. Bovill stated generally that to his knowledge no part of that patent had been anticipated. Mr. Nasmyth said he did not know whether or not holes had been used in the top stone when it was fixed; and no evidence that I can recollect—I shall be glad to be reminded of it if there was any—was given on the part of the defendant. It is urged that upon that evidence you ought to come the conclusion that it was old. I will only remind you that there is a description given of stones, 'which open into the furrows on the face of the stone and are led away to the eye or back of the stone, where the air is introduced. These pipes I prefer to have of about one inch in diameter, and as many in number to the furrows in the stone, so as to give a free ventilation in addition to the supply of air down the master lines from the eye of the stone.' Then he excludes stones like those of which, I think, one is on the table now. He acknowledges there were holes in the running stone; he says he does not claim with respect to them. I do not propose to make any further remarks upon this part of the case; it rests altogether on the evidence, such as it is, on the part of the plaintiff. I have not heard any evidence—I do not recollect any evidence—on the part of the defendant as to that."—Mr. Williams: No, my lord.

"Mr. Justice Willes: It is therefore the argument of the counsel against the evidence, such as it is, on part the of the plaintiff, and it is not wrong to observe that this was the part of the case upon which at one time it appeared, although erroneously, that the least strength of the contest lay. I believe I have now disposed of the question of No. 1. Of course a patent must be new in every part in order to be a good patent. It may be, as has been suggested, that this portion of the process ought to have been included in the specification; and of course if a thing is of the same nature, although it may not be exactly the same thing, it is not new.

"On the other hand, it is important that patentees should not put in their specifications things which are not new, so as to hamper persons who have to do with the subject. It is for you to say what your opinion is upon that state of the evidence as to No. 1.

"Now I come to No. 2. No. 2 is the exhaust. Now with respect to No. 2—I shall not read it over, because it has been read over so many times that reading it again would not produce any greater impression upon your mind, but would rather tend to weaken it—I must remind you that No. 2 consists of the application of an exhaust to the millstone-case, the application of the exhaust so as to draw away the stive and hot air, and to take it off and send it on: what is done with it afterwards is dealt with by No. 3. Now I must at once say, that if the description of No. 2 had stopped there, I should have directed in point of law a verdict for the defendant, because every part of the description in No. 2—the elements of every part of it—was in existence as part of knowledge before the patent was taken out. There was drawing of air through the eye, and passing air through the stone, and there was the application of that exhaust to the millstone-case. Having made that remark, I apply to a vast mass of evidence that was necessarily given on the part of the defendant. Of course the defendant's counsel could not introduce his case of infringement to you without showing the arrangement to which resort had been made, and therefore over and over again the evidence naturally refers to the application of the exhaust. The entrance of the stream of air sometimes between the stones, as in the case of Mr. Potto Brown's application of the exhaust, and in some cases the application of a blast of air whether through the stone or outside the stone, occurred over and over and again. And with respect to all that evidence, it follows that the question is not whether the exhaust was used; the question is, whether the exhaust was so used as to constitute, taking it in the way put by the counsel for the defendant, an anticipation, or, as he says, supposing it to be done now in the same way, an infringement of Mr. Bovill's patent. Having excluded that from the invention—the inventive part of No. 2, and also having removed, as much as possible, any confusion that might be introduced, and speaking only of whether the mechanical elements of Mr. Bovill's patent had been used before, let us see what Mr. Bovill's patent is.

"Mr. Bovill's patent has been commented upon by various learned persons. I prefer reading to you shortly from the judgment of the Master of the Rolls, actually what he says as to the invention of Mr. Bovill, and you have had read other parts which I shall not repeat. That strikes me as being the shortest and clearest way of showing you what Mr. Bovill alleges to be, and what it has been decided that—and it must be at present taken—his patent is:—'The invention consists in producing a blast of sufficient power and exactly so regulated as to exhaust the hot-dusty air from the millstone-case, and drive it with a stive only into a shaft, where it may be utilised and prevented from injuriously affecting the air in the body of the mill.' There are some other consequences which I need not refer particularly to. Therefore, the patent which we are to consider is a patent, the invention and the merit of which consists in suggesting that the exhaust ought to be so regulated as to take away what the blast introduces. Now, I have only one word to say upon the description of the patent. I have carefully read this specification for myself; and, again speaking with the deference which is due after so much greater an authority has expressed his opinion upon the matter, I take upon myself to say, that I humbly concur in the judgment of the Master of the Rolls in saying that this second part of the patent does apply to an exhaust—applied not only in conjunction with a superadded blast, but in conjunction with any blast at all, whether superadded or not, whether it is a blast caused by the action of the stones upon the air, setting it whirling, subjecting it to the centrifugal force, the air entering through the eye of the stone, the exhaust drawing off the air which is introduced by such a blast as that,—I see no reason for confining the word 'blast,' in the specification, to a superadded blast and find nothing in the specification to authorise me to express any doubt as to the propriety of that decision. Now, therefore, the patent is for the application of an exhaust, regulated in such a manner as to carry off—call it the plenum—I should call it the 'wind' produced by the blast coming in; that is, an exhaust regulated according to the force of the blast used to go through the stones. Then anybody hearing that, would say that that was in contradiction to what I said before, because that is a mere idea, and therefore there can be no patent for it. But I must tell you that that question also has undergone discussion, and it has been considered, after that subject underwent investigation, that this patent is a valid patent in that respect, for reasons which it is not necessary to go into at large, because it is not the question before us. But it is proper that I should tell you that it has been held that the patent not only claims that it suggests the idea, and that the idea is a useful one, but that the patent also points out the means by which it can be attained. Now this part of the patent has been applied, as we have heard, in a great many places. As we have learned the idea existed in the earlier patents, and if the evidence for the defendant were out of the case, and that of the plaintiff stood alone, it would seem that until the year 1849 means were not suggested by which the idea could be brought to perfection. That idea was brought into practical use and benefit in a mill in 1845; the super-added blast and exhaust were used in Mr. Bovill's patent, you see, but afterwards the exhaust was used alone. Now I will leave that, with the exception of one remark. It is perfectly true, as was contended on the part of the defendant, that Mr. Bovill had no right to take out a patent for this, as if it were a new idea. A man who puts together old elements in a way to produce some new result, or even an old result, provided it is accompanied by conditions more favourable than were attained by the old method, it would be equally the subject of a patent. A man who takes out a patent in such a case ought to state that his patent is not for a new process, but for improvements: that is what he is bound to do. I quite agree with what was stated; but then when one turns to the specification, as I read it, it is an invention "for improvements in manufacturing wheat and other grain and meal into flour." Therefore, though I tried to understand it at the time, I do not quite see the force of the remark about the patent not being for improvements. The result is, to remove any erroneous impression that might remain: that anybody who, after that patent, worked by the aid of Mr. Bovill's suggestions in the specification, and in his manner regulated the exhaust so as to hit the bull's eye at once, and produce the beneficial result without fumbling or wandering, or being obliged to make experiments to get at it himself, would infringe the patent, and nobody else would. The infringement, in that sense of the question, is not a very serious one; however, it is one of very great importance no doubt as affecting the alleged inventor upon the one hand, and a large and respectable body of men on the other, who would be affected by it, and from whom he would be enabled to demand a royalty if they wished the advantage of using the process in that way. I am sorry to have been obliged to go into that explanation but from one or two expressions which grated upon one's ears, I was desirous to lay the matter before you exactly, even with the detail which might not have been necessary but for those expressions, which I dare say were uttered in the anxiety of counsel to do their duty to their clients.

"Now I come on to the third; and with respect to the third question, I am not assisted by what has been done in any other court that I know of. I am not at all assisted with reference to whether this third part of the invention has been construed as being to be taken with the second part of the invention or not; that is to say, whether the third claim is a claim of straining the stive or air charged with flour, through suitable porous fabrics or not. I do not wish to go through a legal judgment as to my reasons for thinking so; but my impression at present is—and Mr. Williams was quite right in thinking it was—that the first part of the patent, which is mentioned before the second, and has no reference to it that I can satisfactorily make out, is a separate and distinct claim. My present impression is, that the third part of the invention is a claim to use a chamber in connection with the exhaust. The terms in which the exhaust is mentioned in the third claim are so nearly identical with the terms in which the exhaust is described in the second, that if I were to pronounce a judgment upon the matter now, I should say my inclination is, that it was intended to use the third in conjunction with the second. But as the defendant's counsel take another view of the matter, and as the form of the questions sent by the Master of the Rolls will enable you to return a verdict separately, if you think it right, as to each head, and also generally as to the whole, you will be at liberty—if you think that, either as to the first or third head, it ought to be rejected for want of novelty—to say nevertheless, if you think so, that the invention as to the fourth question, or as to the second, was new. The third I need not read to you again; you have it before you; it has been read over twice to-day, and it was also read in other parts of the case. With respect to the third question, you have the evidence of various witnesses, and you have also the reference made to the patent. With respect to the third, as with respect to the others, I shall ask you what you say to it separately, and also what you say to it in combination.

(*To be continued*).

## MR. HOWARD, M.P., ON PATENT LAWS.

This difficult subject has lately attracted the attention of the House of Commons, and, in an interesting debate on the 28th May, Mr. J. Howard, M.P., so well known as a successful inventor, gave his views upon the question. These views appear so well worthy of attention, that we give a corrected report of his speech below:—

Mr. J. Howard said he thought the hon. member who had introduced the subject had been singularly fortunate in finding so able a seconder as the right hon. and learned member for Richmond. He had listened with much attention, and no little interest to the objections and views, not only of the hon. member who had brought forward the motion (Mr. Macfie), but also of the noble lord opposite (Lord Stanley), and of the hon. and learned gentleman who seconded it (Sir R. Palmer). It appeared to him that most of the arguments that had been urged did not touch the principle of a patent law, but went rather to the defects of the existing law and its administration. In dealing with the objections raised by the hon. and learned member to the principle of a patent law, he felt at how great a disadvantage he stood in having to combat the views of so able and distinguished a man; but it appeared to him as a plain practical man that the arguments used were more subtle and theoretical than sound. He maintained that the greater portion of the arguments of the right hon. and learned member did not apply to the principle of a patent law which he had assailed, but to the defects of our present system. If we would condescend to borrow some ideas from America, many of the objections which have been urged to-night would fall to the ground. A greater part of the evil complained of resulted from the sham examinations which now took place on the application for patents. The hon. and learned gentleman said it was impossible for the law officers of the Crown to institute a proper inquiry; but seeing that they received about £16,000 a-year for that duty, it was desirable to know why it could not be performed. Again the Act of 1852 made provision for the appointment of additional commissioners, but this had not been carried into effect, consequently patentees had great cause to complain of the administration of the law. The difficulty in trying patent cases mainly arose from the loose and imperfect way in which the specifications had been permitted to be drawn up, so that it was impossible to say what was new and what was old in them. He was prepared to show the House how these evils might be remedied, and these difficulties overcome, but this was neither the time nor the occasion to do so. The honourable and learned gentleman had alluded to the three great inventions of the age— the steam engine, the electric telegraph, and the screw propeller—but was he prepared to maintain that these inventions would have reached their present state of perfection without the stimulus of the patent law. One objection urged against the patent laws was, that patents gave a monopoly, and acted as a restraint upon trade. He admitted that as at present administered, they did so; but if the State in granting a patent gave no exclusive right, and patentees were obliged to grant licenses on reasonable terms, to be settled by an independent body, this objection would be removed. There existed under the present system what is termed "dog in the manger" patents, which are an unmitigated evil, and should be swept away. The hon. and learned member had also alluded to an important and well-known invention in the grinding of corn, and had, he would say, jumped to the conclusion that it could not long have remained undiscovered, but he would ask what grounds had he for this assertion? The fact was that the world had gone on for 3,000 years grinding corn without any material improvement in the method until a man of genius like Bovill arose to make the discovery, but who, owing to the disgraceful state of our laws, was afterwards worried to death by litigation. Although he did not agree with the conclusions arrived at by the hon. member for Leith, he felt indebted to him for having brought the subject before the House. Much misapprehension undoubtedly existed in the public mind on the question of the patent laws and their administration. This discussion would enable hon. members to clear away some of the mist and doubt that prevailed. It appeared to him that the main arguments had tended to show the necessity for an amendment rather than an abolition of the existing laws. That the patent laws as they now exist, and as they are at present administered, are open to grave and serious objections, he readily granted; but that their abolition would result in advantage to the country, or to the welfare and interest of any particular portion of the community, he altogether disbelieved. It must be remembered that England has at the present day most formidable rivals in France, Germany, America, and Belgium, and that her manufacturers and workmen have to compete with the manufacturers and workmen of these countries who have availed themselves, not only of the best English models, but have adopted those facilities for rapid production originated in our English workshops, and hitherto peculiar to them. The only chance the English manufacturer has of maintaining his place in the race, is by adopting improved designs—finding out means to reduce the cost of his productions, and introducing improved plans for securing perfect workmanship. These objects can only be attained by much thought and great effort of the brain; and, as the race is a close one, and every year is becoming closer, it appeared to him that instead of the State taking away a stimulus to invention, the nation is deeply interested in finding out in what way inventions and discoveries can be further stimulated, how research and means of improvement can be extended not only to the higher class of inventors, but to our working population, among whom thousands are to be found of a mechanical or scientific turn. This was abundantly evident to all who had visited the industrial exhibitions of working men's productions in London and elsewhere. When in Washington some two years ago, no building he had seen in the States made such an impression on his mind as the Patent Museum in that city. It was so superior to anything of the kind in England that he felt almost ashamed that our old country was so much behind the new. This museum was in fact a great educational establishment, to which not only the inventors, but the public resorted for information. Every patent for which the United States had granted letters was not only classified there, but models of the inventions were arranged chronologically; while in another spacious and beautiful apartment were models of all the rejected patents, so that any one could go into that museum and trace the progress of the various inventions step by step. He could not help thinking that a similar establishment in England could not but have considerable effect on the national weal. The noble lord opposite, and the hon. and learned member for Richmond had drawn a somewhat subtle distinction between the production of a book and a machine, or other invention; it appeared to him that a book, a piece of music, a painting, and an invention, are all alike products of the brain; and the natural right of the author of a mechanical invention should be recognised by the State as fully as that of the author of a book. The noble lord had said no two men ever wrote the same book at the same time, which is undoubtedly true, but he had frequently found that two authors writing almost simultaneously conveyed precisely the same ideas, though not in the same language. Exactly so, if two men invented similar machines simultaneously it was never found they carried out their ideas precisely in the same mechanical way. With respect to the statement of the hon. and learned member for Richmond, that the laws of nature were the common right of mankind, which must be freely admitted he held that the argument based upon it was untenable. The inventor made use of the laws of nature just as the author of a book used the common language of mankind. He might be obtuse, but for the life of him he could not see that the cases were not strictly analagous. He would ask hon. members who were unacquainted with mechanical subjects what would be the effect of abolishing the law of copyright. Would the literature of the people be thereby enriched—would the taste of the country be improved? He believed the abolition of the patent laws would have in mechanical, chemical, and other industrial pursuits, precisely the same effect as the abolition of the law of copyright upon literature and the fine arts. The hon. member who introduced this subject said he would not withhold compensation from a meritorious inventor, but he would ask who was to decide the knotty point of merit, and its money value? At present the State very wisely left this to be decided by a discerning and purchasing public, and he believed it would continue to do so. To his mind it would altogether be *infra dig.* to him, personally it would be revolting to have to go, cap in hand, to the Chancellor of the Exchequer, or some other state official, to press his claim for compensation, or get some powerful political friend to do so for him. No—from past experience of Government treatment, inventors would never consent to be left to the tender mercies of a State department, but will prefer to confide their claims for reward to a discriminating public. That the patent laws and their administration should have been left so long unreformed is a scandal to former Parliaments. The machinery is costly, cumbrous, and withal uncertain and inefficient. Inquiries have been made, and a Royal Commission years ago passed condemnation, and suggested reform; but nothing, or next to nothing, has been done. We have the finest library of patented inventions in the world, yet the bulk of it was stowed away in a passage six feet wide. He knew it well, having often been there. It was really a passage just 6ft. 3in. wide—and formerly led to the offices of the Master in Chancery. Could it be believed that such a state of things had been allowed to exist when, since the passing of the Patent Law Act of 1852, the surplus revenues of the office has been over £650,000, but a fraction of which had been expended for the benefit of inventors who had contributed the money? He held that the surplus should be devoted not to increasing the general revenue but to promoting patent objects and the general advancement of science. He thought, as he had previously stated, this was scarcely the occasion for entering into detail concerning the improvements necessary in our patent laws, but expressed a hope that when the subject was taken in hand by the law officers of the Crown, and he had reason to believe they would take it in hand next session, they would provide the means for a *boná fide* examination of all inventions before patents were granted, and also provide that the specification should be so clear that the public may know what really the patent was granted for, and thus save the ruinous cost of legal proceedings. He would conclude by declaring his deliberate conviction that if they wished to undermine the manufacturing and commercial greatness of England, they could not take any more effectual mode of doing so than by abolishing the patent laws.

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## THE ATLANTIC AND PACIFIC RAILROAD.

A gentleman who has lately travelled from New York to San Francisco without stopping, or, rather, without breaking his journey, gives the following rather highly coloured, but interesting account of his journey. It will be seen that, so far from finding the journey irksome, he is of opinion that ladies, and even invalids, could perform it with ease. How far this opinion is due to robustness of health possessed by the writer we will not attempt to estimate, although it is evident he is by no means delicate:—

"Having made the journey across the continent from New York to this city, I can assure those who purpose making it that there is no strain at all in it. The journey is a delightful one, even for ladies, and the weakest invalid would be strengthened by it. There is a constant succession of novelties. Starting from New York by the route I travelled (the Pennsylvania Central), the traveller is taken through Trenton and its vicinity, in New Jersey, through Philadelphia, and Harrisburg, over the beautiful Alleghany Mountains, and through the busy iron and coal regions of Pennsylvania. A glimpse is given of Pittsburg, the Manchester of America, in soot, smoke, dirt, and immense shops sacred to Vulcan. The Railroad, now changed to the Pittsburg, Fort Wayne and Chicago line, takes the stranger through one of the most delightful and beautiful countries, in the State of Ohio. Chicago, 910 miles from New York, is reached after 43 hours' travel. Chicago is the representative inland city of America in the marvellous rapidity of its growth, in its daring enterprise, in its varied railroad connexions, and in all that goes to make up a live Yankee go-ahead city. The distance from Chicago to the Missouri river and Omaha, the initial point of the Pacific Railroad, is 490 miles, and the cars of the Chicago and North-Western Railroad make the trip in 22 hours, conveying passengers through the great rich and deep pastures of Illinois and Iowa These lands, when first their virgin freshness was broken by the plough, yielded 50 to 60 bushels of wheat to the acre.

"The Omaha and the Union Pacific Railroad are reached after a passage across the muddy and tortuous Missouri river, and now the great plains are reached, called the great American Desert. There is a great sameness about the journey now, but the dryness and exhilarating qualities of the air, the beauty and variety of the cloud effects, compensate the traveller for this sameness.

"At Laramie, 562 miles from Omaha, the Rocky Mountains proper are reached. The railroad company selected a line through that route which offered easy grades, and the tourist will be rather disappointed at not seeing such mountains as the Alps in Colorado. Such mountains he can behold, however, further south, but not near the railroad line; and yet the scene from Sherman, the point of greatest altitude on the entire road—8,242ft. above the level of the sea—is one which can never be forgotten: distance seems to be annihilated by the transparency and purity of the air; the entire chain of mountains, with their every ravine and projection, are cut so clearly and distinctly that objects which are 20 miles distant seem to be but five or six. Then there are great expanses of valleys stretching away between the main ranges, giving the idea of boundless distance and of a boundless land. The "watershed" of the continent, at Bridge's Pass, is reached in two days and a half from Omaha, and now all water runs Pacificwards. The journey through Weber and Echo Canons is one of the most weird and frightful possible. The line winds along the side of deep chasms, over roaring torrents, under overhanging mountains, round towering cliffs, past wonders of nature in her wildest moods, with beauties of mountain scenery unsurpassed probably anywhere. Then comes the great valley of Utah, with its wonders of Mormon tillage and irrigation. The Great Salt Lake shines like a huge mirror in a setting of lofty mountains. At Promontory Mountain we reach the junction of the two lines which constitute the through Pacific Railroad from Omaha to San Francisco. The cars of the Central Pacific road are now taken: this company controls the Western or Pacific, and by far the most valuable, half of the transcontinental line. And now, through Utah and Nevada, we have alternate stretches of circular plains and mountains of rounded forms; we pass the river Humboldt, known as the river of death to early immigrants to California; and, finally, the Sierra Nevada Mountains are reached. They are truly grand and precipitous. Magnificent crests, eternal snow, beautiful lakes, silvery waterfalls—all, in fact, mountains can exhibit that is lofty, beautiful, and imposing. Now, when the trip is drawing to a close, its greatest beauties, and by far its greatest difficulties, are seen on the road. The summit of the Sierra is crossed at an altitude of 7,042ft., and this altitude is attained in a distance of 112 miles locomotive climbing; and the highest engineering science was, therefore, necessary at this place. The journey to the ocean is now rapidly downward—so rapid, indeed, where there is a descent of 116ft. to the mile, that steam is altogether shut off and the breaks partially applied. In 6¾ days from New York the traveller westward is landed at San Francisco; and in a short time, when close connexions and some improvements are made, the journey of 3,181 miles may be made in less than six days.

"The sleeping car arrangements are now in perfect order. Everything connected with the beds is of the most luxurious nature. In addition to the sleeping cars, eating hotel cars are now provided. A description of one of these cars appeared in the *Evening Bulletin* a few days ago, as follows:—

"The car is about 60ft. long by 10ft. wide, supported on eight-wheeled trucks, giving 16 wheels to each car. This arrangement and an elaborate combination of steel springs give such steadiness that no serious jolting unsettles a dish. The exterior of the car attracts attention chiefly by its appearance of solidity. Constructed of the best materials, at a cost of nearly 20,000 dollars, and braced and secured in every conceivable manner, it seems almost absolutely free from the casualties of an ordinary riding car. In the only case where a Pullman car has been known to leave the track in company with its train, it rolled down a 40-feet embankment, sustaining no other injury than the breakage of glass on one side and a few scratches and bruises. No passenger sitting in it suffered anything worse than a bruise*. As the car did not break, and was neither twisted nor strained out of line, it was ready for immediate service when restored to its place on the rails. The uses of the dining car are indicated by its exterior decorations, in carvings and paintings, representing fruit, fish, game, and other edibles. The interior is elegantly finished in black walnut, mounted with silver wherever metal is essential. Seats for dining 48 persons at once are arranged at 12 separate tables, on each of which is abundant space for the service of four persons. These tables are portable, and may be removed and stowed away out of sight at a moment's notice. At either ends of the car are water tanks, closets for wine, canned fruits or condiments, ice-boxes for cooling wine, and the usual toilet arrangements so that the traveller may remove the dust from hands or face before sitting down to his meal. Midway between the two ends of the car, and occupying its entire width, with the exception of a narrow passage, is located a compact kitchen, especially designed for the Pullman car, and fitted up with every possible contrivance and facility for preparing food quickly and well. Its success was amply demonstrated in its trip across the continent, for nothing could be better than the meals placed before the party three times daily. Immediately beneath the kitchen floor, and communicating by trap doors, are dust-proof ice boxes and provision cellars. Here are packed the fresh meats, the butter, eggs, and other edibles requiring cool quarters for preservation. Spacious water tanks are connected with the kitchen by a force-pump; and the cook and his assistant have everything at hand, almost without turning round. Entering the car to dine, you take your seat. At your side you find a bell. One stroke upon it, and a waiter, neatly clad in white jacket bearing the monogram of the Pullman Company, appears and presents you a bill of fare. Your order is filled, and your savoury steak of beef or antelope, your mountain trout or boiled chicken, are placed before you smoking hot. Wine, tea, coffee, or fresh milk are also at command; and for sauce, what can be more appetising than the air of the Rocky Mountains and the elevated interior plains of the American continent, except, possibly, the reflection that you may enjoy your meal in elegant leisure while the train bears you swiftly forward towards your journey's end? A traveller may obtain a 'good square meal' of plain food for the dollar or a dollar and a quarter which is charged at the station restaurants, while those who desire only a light lunch can command it at trifling cost."

## KING'S LYNN DOCK.

This dock, which has been in the course of construction by the King's Lynn Dock Company since March, 1868, was opened on the 7th ult. by their Royal Highnesses the Prince and Princess of Wales. The scheme had long been under consideration, but it was not until June, 1865, that a company was incorpated for carrying it out, the capital authorised being £88,000, to be raised, £66,000 by stock or shares, and £22,000 by debentures. Possession of the ground was obtained in October, 1867, and Mr. Lawrence, the contractor engaged, proceeded to carry out the comprehensive plans which had been prepared by Mr. Bunlees, C.E. The stream known as Fisher's Fleet had to be diverted as a preliminary measure, and in March, 1868, the foundation stone of the outer sea wall was laid by Mrs. Jarvis, wife of Mr. L. W. Jarvis, the chairman of the company. By the close of last August the coffer dam across the entrance was completed, and in November the excavation of the lock was commenced. On 19th June, the dock walls, basin, and lock were completed, and the tidal water was admitted through the coffer dam at the entrance, the whole work having thus been executed in about 15 months. The water area of the dock basin is 6½ acres. The form is that of an irregular quadrangle, the southern side being 780ft. in length, and the northern side 590ft.; the width from north to south between the edges of the quays is about 440ft. At the water surface the width is 420ft., and the average depth of the dock is 31ft. The dock is not surrounded with perpendicular quay walls, but has banks with an inclination of 1½ horizontal to 1 perpendicular, the slopes being faced or paved with solid blocks of concrete. Small craft can get up pretty close to the quays, and to accommodate vessels of considerable draught seven substantial timber jetties have been constructed—four on the south side and three on the north side. Each jetty is 16ft. wide and 32ft. long, and the floors are furnished with rails leading to the lines round the dock, which are to be brought into easy communication with the Great Eastern system. The second jetty on the south side is furnished with a six-ton crane. The earth excavated from the dock and basin was used in raising the surrounding land to a height of 9ft. above its former level, forming a valuable wharfage area of about 25 acres. The concrete blocks used in facing the dock basin are 4ft. square and 15in. thick, and they are composed of Portland cement, sand, and shingle. Of these blocks 5,000 were used; they are placed on a layer of concrete and jointed with cement; the foot of the sloping wall or pavement thus formed rests on a foundation of church stone, bedded with concrete, carried down from 2ft. to 4ft. below the bottom of the dock. The dimensions of the entrance dock are—width, 50ft.; length between gates, 200ft.; depth, 30ft. The foundations are carried down into the Kimmeridge clay, and the bottom is an inverted arch of massive brickwork, 5ft. 6in. thick, fronted with quoins of stone. The side walls are 12ft. 6in. thick at the base, and are gradually reduced to 5ft. 6in. at the summit, with several outer buttresses 2ft. 9in. thick. The end walls of the lock are 16ft. thick at the base and 5ft. thick at the top, and they are 33ft. in height, the foundation being about 2ft. below the bottom of the dock basin. The sea walls rest on foundations of concrete blocks, and the base is strengthened by rows of sheet piles driven 5ft. below the foundation. The faces of the walls are protected by timber work. From the lock entrance the sea walls extend 240ft. each way north and south, but beyond this distance additional wing walls of carstone and church stone have also been erected. The platforms on which the lock gates are to work are 9ft. 9in. below low water of average tides, and are very substantial; the stone used being the Bramley Fall. The gates were put together on the spot, the ironwork being supplied by Messrs. Tod and Son, of Edinburgh; each leaf being 29ft. wide by 31ft. high, and 2ft. 9in. thick in centre, the framework being of oak and the remainder Dantsic fir. The heel-posts were formed out of timbers originally 44ft. long and 22in. square. Each leaf weighs 25 tons, and swings on pivots of wrought iron working in gun-metal sockets, being supported also at the front edge on rollers running on a curved iron tramways. Capstans are provided for opening and closing the gates. Each leaf has also two iron sluices for letting in water into or out of the dock and for scouring it and the outside channel.

## OPENING OF THE NEW ALBERT DOCK AT HULL.

On the 22nd ult., their Royal Highnesses the Prince and Princess of Wales formally opened the new western dock at Hull, the last addition to the extensive dock system of that port. The first stone of the new dock was laid in 1863, and towards the close of June last the dock became ready for use, so that it occupied altogether six years in its completion. The cost was about £1,000,000, of which £354,600 has been raised by bonds and the remainder by shares. The basin of the Humber dock forms the entrance to the Albert Dock, but to enable it to meet the increased demands made upon it, it has been enlarged so that it is now 1,000ft. in length by 300ft. in width. The lock is one of the largest in England, the chamber being 320ft. long and 80ft. wide. The depth of water in it at spring tides will be 30ft., and at neap tides 24ft. The lock is enclosed by two pairs of wrought-iron gates, worked by hydraulic machinery. Separate machinery is fitted to each pair of lock gates, and on the piers opposite, capstans are erected, worked by hydraulic power placed beneath; in case of accident to the machinery, provision is made for manning the capstans in the ordinary way. A footpath 4ft. wide running along each gate will afford a ready means of crossing the lock, which can be filled in 3½ minutes only, ten sluices being necessary for this operation, while two of the same capacity will as quickly empty it, although the ordinary time for filling and emptying the chamber will be five minutes. The four sluices form arched culverts, and are each 7½ft. high and 6ft. wide. Opposite the engine-house, on the south side, a wrought-iron swing-bridge will be thrown across for general traffic, and will facilitate communication with the town and between the north and south sides of the dock. The bridge will be worked, like the dock gates, by hydraulic power. The south-east pier of the lock which stands in the Humber basin is faced with wooden framing; the opposite pier is built of Bramley Fall stone, which has also been used for the most part in the construction of the dock walls. Upon the south side a large ice warehouse will be constructed, and to the west of this a platform 48ft. wide will run for a length of 700ft.; this platform, which is intended for the accommodation of the fish trade of the port, will have offices and storerooms overhead. On the north side of the dock is what is known as the Railway Creek; the north side of this creek has been allotted for the use of the Manchester, Sheffield, and Lincolnshire Railway Company, and the south side is to be occupied by the North-Eastern Railway Company. These arrangements have been rendered necessary in consequence of some previously existing railway premises having been absorbed into the dock works.

The dock was designed by Mr. Hawkshaw, C.E., who has been assisted and represented during the undertaking by his son, Mr. J. C. Hawkshaw: it is 3,300ft. long, and is of a somewhat singular shape, being 430ft. broad at its widest part, and only 180ft. wide at its narrowest part; its area being 23a. 0r. 1p., thus making the entire dock accommodation at Hull 84a. 0r. 16p. There is a large amount of quay space all round the dock, and the average width of the quay is no less than 100ft., while in some parts the width is more than 150ft. On the north side, not far from the entrance to the dock, Custom-house offices will be built, and it is also proposed to erect in succession several warehouses and sheds, the first of which is being carried out under the superintendence of Mr. R. A. Marillier, resident engineer. Considerable difficulty has been experienced in getting a good foundation, and the walls of the dock have been laid in some places on no less than 20ft. of concrete and in other places on 8ft. of concrete. In the case of the warehouse, which is being executed under the direction of Mr. Marillier, it was found necessary to raise the north wall superstructure on Memel piles 34ft. in length. The iron columns forming the intermediate supports of the upper floor beams are fixed upon large blocks of Bramley Fall stone, which are also supported on piles. The warehouse is 400ft. long and 50ft. wide; and it will consist of two stories. About 450ft. from the inner gate of the dock, and midway between the north and south walls, a substantial mooring dolphin has been placed for the purpose of assisting in docking and undocking ships. Running by the rear of the warehouse and street leading away to the west is the dock railway, which will be a double line all round the dock, while in some places four lines of rails will be laid. A few hundred yards from the west end, the dock railway joins the North-Eastern system, and thus brings the dock in direct communication with every town or village to which foreign produce may be despatched, or from which home manufactures, &c., can be received. At the west end of the dock the walls are of a very easy pitch. It may also be remarked that beyond the west end the Dock Company owns 115 acres of foreshore, which will be available for the purposes of further dock extension, if necessary. The south side of the dock stands on a site reclaimed from the Humber. With a view to the protection of the dock, such masses of the excavated material as were not used in backing up the dock wall went to form an embankment outside the wall of the foreshore. This other embankment, or quay, is about 100ft. in breadth and next the Humber, for the greater part of its length, it has a sloping wall, faced with stone; it is thus rendered a highly valuable defensive outwork for the protection of the dock. The remainder of the river frontage of the embankment, which runs for a length of 1,700ft., is piled, the piles being backed by solid earthwork. The western end of the south wall of the dock for a distance of 1,300ft. is made of a sloping bank, pitched with stone. At intervals jetties project from the south sloping wall; two of these jetties are furnished with coal tips, which are to be worked by hydraulic power. The engine and boiler houses stand upon piles, and consist of a plain single-storied erection with three compartments, being respectively the boiler, engine, and accumulator house The boiler-house is 50ft. long by 37ft. wide; the engine-house is 37ft. long by 19ft. wide; and the accumulator-house is 16ft. square. The engine is a 40-horse double cylinder one, and will supply water for the whole hydraulic machinery used in connexion with the dock. Water will be pumped by the engine at a pressure of 700lb. to the square inch; and the engine is so arranged that one-half its power can be retained for pumping water to the machinery, while the other half, through the connecting of an additional pump, can be used for the purpose of supplying water to firepipes laid round the whole dock. The whole of the machinery worked by the engine has been tested to a pressure of 2,500lb. to the square inch. The water finds it way through 5-inch and 3-inch pipes round the whole dock, and, after it has been used, it returns to the accumulator, and can be used again and again. There are three boilers in the engine-house, each being 20ft. long by 6ft. in diameter; the accumulator is on Sir W. Armstrong's patented principle. Eight hydraulic engines, each of 8-horse power, are placed round the lock to work the gates, and four of 10-horse power each to work the capstans, Four of these capstans, two above and two below the inner dock gate, are fixed to haul ships in out of dock, and they will exert a strain of three to five tons each upon a hawser. The dock gates are 30ft. high and 50ft. long, and they are built of boiler-plate and in compartments 13ft. long by 2ft. high. Each leaf weighs 105 tons. Three small sluices measuring 2ft. by 18in. are set in each leaf to assist the greater sluices, and to clear the sills. The bridge before referred to will be of the wrought-iron girder class, and it will be 145ft. in length, while the width will be sufficient for a single line of railway with a footpath on each side. The whole of the hydraulic machinery has been supplied by Sir W. G. Armstrong and Co., of Newcastle-on-Tyne, and it has been fixed under the superintendence of Mr. C. Waure. Mr. W. M'Cormick has been the general contractor for the dock works.

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* We imagine this must have happened after the occupants had dined.

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## HER MAJESTY'S SHIP "MONARCH."

The *Monarch*, armoured iron-built turret ship, 7 guns, 5,102 tons, 1,100-horse-power (nominal), was put through her speed trial under full-boiler power over the measured mile course in Stokes Bay, near Portsmouth, on the 17th ult., under the supervision of Captain E. B. Rice, aide-de-camp to the Queen, commanding the steam reserve division at Portsmouth. Upon starting for her trial she drew 21ft. 10in. of water forward, and 25ft. 8in. aft. She had 567 tons of coals in her bunkers, and was complete for sea service in all respects in rig, armament, stores of all kinds, and crew. The officials on board in connexion with the trial were Mr. James Lnke, Admiralty surveyor; Mr. J. Barnes, assistant constructor of the Navy; Mr. J. Steil, Admiralty inspector of machinery; Mr. W. Eames, engineer and inspector of machinery, Chatham yard; Mr. John Ward and Mr. G. Murdock, chief inspectors of machinery of the Portsmouth Steam Factory and Reserve Departments. After a narrow escape from collision with a yacht, which threw her out of her course so far that the runs that had been previously made had to be discarded, six consecutive runs were made over the measured mile, the results of which gave the subjoined figures:—

First mile.—Speed of ship, 13·740 knots; revolutions of engines—per minute, 63·90; per mile, 279.

Second mile.—Speed of ship, 16·216 knots; revolutions of engines—per minute, 62·70; per mile, 232.

Third mile.—Speed of ship, 13·636 knots; revolutions of engines—per minute, 63·88; per mile, 281.

Fourth mile.—Speed of ship, 16·216 knots; revolutions of engines—per minute, 62·70; per mile, 232.

Fifth mile.—Speed of ship, 13·636 knots; revolutions of engines—per minute, 65; per mile, 286.

Sixth mile.—Speed of ship, 16·290 knots; revolutions of engines—per minute, 63·53; per mile, 234.

Mean rate of the ship's speed, 14·937 knots per hour. Mean indicated horse-power, 7,842.

After the six runs had been completed, the steam steering gear, fitted under M'Farlane Gray's patent by Messrs. Forrester, of Liverpool, was applied to the steering of the ship, which had hitherto been done by ordinary manual labour at the wheel, and a couple of circles taken with it with the following results:—

First Circle.—Helm over to starboard, to an angle of 38 deg. in 20 seconds. Half-circle made in 2 min. 12 sec., and the full circle in 4 min. 44 sec.

Second Circle.—Helm over to port, to an angle of 36 deg. in 31 seconds. Half-circle made in 2 min. 17 sec., and full circle in 4 min. 36 sec.

With regard to the steering and turning powers of the *Monarch*, nothing could well be more satisfactory than the quick manner in which she obeys the slightest motion of the helm, or the rapid manner in which she brings round her stern in turning, but in the course of the day's trial, especially when the helm was put over to starboard to avoid collision with the yacht, it was evident that if the helm was put over to a greater angle than 25 degrees, the ship would take charge of the balanced rudder, and refuse to change the direction in which she was moving until her speed was slackened, whatever might be done in the meantime with the helm. This is a serious defect in the balanced rudder, but it has been exhibited before, and notably on the six hours' trial of the *Hercules*, when, in putting her stern to the wind and sea to run back her course eastward from the "Bill" to the Isle of Wight, the ship took charge, and for nearly half an hour cut "figures of eight," to the infinite amazement and terror of the crews of several collier brigs who were in company at the time.

The *Monarch* is a ship that must be of considerable interest to the general public, inasmuch as she represents official ideas of some three years ago on the description of vessel that could only satisfactorily represent an ocean-cruising turret-ship, and in this respect has been designed and constructed as the competitive ship with the *Captain*, designed and building by Captain Coles and the Messrs. Laird, at Birkenhead. The form of the *Monarch* below the water line is considerably finer than the *Bellerophon* or *Hercules*, and the promise of speed which it gave was full confirmed by the exceptionally high rate of 14·937 knots per hour obtained by her, as a mean, on the 17th ult. She is essentially a turret-ship with a high freeboard, the latter being 14ft. above the water line, and is topped by a (lowering) thin iron-plate bulwark about 3ft. in depth. From the sides inwards to the centre the upper deck is somewhat curved, and the guns in the turrets are thus carried with the axis of their bore about 20ft. above the water. In this great height above the water line of the hull of the vessel and all it carries above-board, the eye is struck with the great amount of target surface exposed to shot. The two turrets which the ship carries are fixed as nearly as possible together between the foremast and mainmast, and with the funnel between them. Each turret has an outer diameter of 26ft. 6in., and internally is 22ft. They are plated with 10-inch armour plates round the ports, and 8-inch on other parts. In each turret are, mounted on compound pivoted iron carriages and slides, two 25-ton muzzle-loading rifle guns of 12in. bore and 15ft. in length. They are exactly balanced at the trunnions, and throw a 600-pound shot with a battering charge of 70lb. of powder. In the ordinary position of the guns in the turrets they have seven degrees of depression and four degrees of elevation. Lowered down to the next position, or "step," they have half a degree of depression, and 9 deg. of elevation. Lowering them still further, and into the deepest position in the turrets, the guns would then have 16 deg. of elevation, such as would be given to them in throwing shells into a loftily-planted fortress. The guns are raised and lowered in the turrets by hydraulic power and by screws. There are four sets of sights to each gun. The time occupied in lifting the guns from the lowest to the highest step in the turret is 3½ minutes, or at the rate of 6in. per minute. Both turrets are based on the main deck of the ship, but all the turning gear is on the deck below. One set of steam gear and two sets of hand gear are fitted to each turret for turning it. In addition to the turret guns, the ship carries five 6½-ton guns at the extreme ends, firing through armour-plated bulkheads. The steam-engines for turning the turrets have been constructed from drawings prepared at Chatham Dockyard.

The *Monarch* is fully, and, for an iron-clad, heavily-rigged, and this no doubt adds to the favourable appearance she makes afloat when lying in an open space such as Spithead. That she will steam satisfactorily has been sufficiently proved by the results of her trial; that she will sail moderately well, with the large area of canvas she is able to spread, may be reasonably expected, and that she would fight a good action with any other ship is certain with the enormous ordnance she carries in her turrets, although her high sides might suffer from an enemy's turret fire.

On the 20th ult., the *Monarch* was tested on her six hours' continuous steaming trial outside the Isle of Wight, the results of which may be taken as corroborating fully the high rate of speed she attained on her measured-mile trial, of very close upon 15 knots per hour. These six hours' trials under steam of Her Majesty's ships outside the Isle of Wight are conducted upon a mere "rule of thumb" system, more puzzling even to its promoters than it is to outsiders. When the six hours, continuous steaming trials of Her Majesty's ships outside the Isle of Wight were first entered upon, the ships were raced during the six hours at their greatest speed of engines between fixed and distance-known headland points, and thus, after allowing for tide, the ship's speed, as well as the continuous capability of her engines, was obtained. Now the test is confined simply to the efficiency of the engines through a six hours' continuous steaming, and the question of exact difference travelled over by the ship during the six hours is entirely shelved. In her run the *Monarch's* engines realized a mean speed throughout the six hours of 62·66 revolutions per minute, and 3,797 per hour. The entire number of revolutions made by the engines during the six hours was 22,561. The mean steam pressure in the cylinders was 19·30lb., and the indicated power of the engines 7,468·40 horse, being rather less than during her speed trial, but a much nearer approximation than is usual in such cases.

The dimensions of the vessel are:—Length between perpendiculars, 330ft.; breadth (extreme), 57ft. 6in.; depth of hold, 18ft. 8in.; displacement at time of trial, 8,070 tons; co-efficient of efficiency by Admiralty rule, 170.

The engines of the ship gave the greatest satisfaction by their work throughout the trial to the Admiralty officials on board. Messrs. Humphreys and Tennant are the makers, and they were represented on board by Mr. Humphreys, Mr. Allfrey, and Mr. Langdon. The engines have a combined nominal power of 1,100 horse. The cylinders have an effective diameter of 120 inches, with a piston stroke of 4ft. 6d. They have return connecting rods, with four pistons. The boilers are nine in number, which have 40 furnaces, the area of grate surface being 770 sq. ft., and the total heating surface 20,900 sq. ft. The superheating surface is 3,600 sq. ft., and the condensing surface 16,500 sq. ft. The screw is a two-bladed "Griffiths," having a diameter of 23ft. 4in., a pitch of 26ft. 4in., and an immersion of upper edge of 16in.

## ROYAL AGRICULTURAL SOCIETY'S SHOW AT MANCHESTER.

This show, which is generally acknowledged to have been the most successful that has ever been held by the Royal Agricultal Society—both as regard exhibits and the number of visitors—came to a conclusion on the 24th ult. The chief prizes offered were for mowing and reaping machines, for both of which there were a great many competitors. Twenty-two pair-horse grass mowers were tried during the 13th and 14th ult., upon a piece of meadow grass by no means difficult to cut, eleven machines being selected for a second competition on the next day. The grass in this latter trial was not a specially heavy crop, though very thick at the bottom, upon uneven ground that formed an excellent test of the capabilities of the different machines; and the half-acre plots were laid out across the ridges and furrows. Lots were drawn for the different pieces of work, and the race began; while the judges, Messrs. John Hemsley, Matthew Savidge, J. W. Kimber, and C. F. Bramwell, C.E., inspected the closeness and regularity of cut, and noted time occupied and number and cause of stoppages; and as each machine completed its task it was subjected to the accurate draught test of Messrs. Easton and Amos' dynamometer.

Samuelson and Co. cut exceedingly well, but, unluckily, broke a knife-section, making their total time 39½ minutes with four stoppages. Hunt and Pickering cut well, and without stoppage—time 33½ minutes. Bamlett's old machine made irregular work, and met with many stoppages. His new machine, however, did especially well. Hornsby and Sons' "Paragon" cut beautifully, particularly in deep hollows and over mounds—time 36 minutes, with several stoppages. Walter A. Wood's American mower, old pattern, made admirable work—time, 34 minutes, with half-a-dozen stoppages. Walter A. Wood's new "Imperial" machine (in which the crank connecting rod and the lever supporting the cutter bar pass through one of the travelling wheels, made without spokes for the purpose) cut beautifully and without a single stoppage, completing the half-acre in 29 minutes. J. and F. Howard's "British" mower left the ground wonderfully close and evenly shaven, and finished its plot in 30½ minutes, with three stoppages. Hornsby and Son's new mower made most excellent work, occupying 35 minutes, with only a couple of stoppages. Picksley, Sims, and Co.'s beautifully made machine also did particularly well; and Burgess and Key's mower, in which all the working parts lie in the most compact form, following the cleared track, cut closely and regularly, occupying 34 minutes, and making three stoppages.

The one-horse mowing-machines of Picksley, Sims, and Co., W. A. Wood, Samuelson and Co., Kearsley and Co., Burgess and Key, Brigham Bickerton, Hornsby and Sons, and the Reading Ironworks Company were tested on the 14th ult. In offering £30 in prizes for these machines, with a view to supplying the wants of small farmers, the Society appears to have overlooked certain practical considerations. The power requisite to drive the reciprocating knife with sufficient speed is so great that the performance obtainable by only one horse compares very unfavourably with that obtainable by two horses; if a farmer cannot employ a team of his own, he had better trust to hiring a neighbour's machine, or keep to the manual scythe; and if his hay crops are always light enough for one-horse mowing he might put his grass land to a better use than growing on it such a thin supply of winter fodder.

The two hundred guineas' worth of prizes offered for reaping machines brought out a bewildering number of inventions more or less novel and meritorious; and, though some odd fancies appeared among the fourscore reapers in competition, there was generally observable a great improvement in details of construction for strengthening, while at the same time lightening machines which are subject to rough usage over all irregularities of hard or soft ground, and for providing against the undue wear of working parts. This wood framing has given way to wrought iron, giving a minimum of weight in proportion to strength; dimensions are more nicely calculated with reference to the different strains, and the liability of different parts to fracture and wear is avoided and time economized by the extensive application of self-acting lubricators to rapidly-moving and other frictional parts.

From a first trial of machines, delivering the cut corn in a continuous swathe at the side clear of the next horse track, a few were selected for a second contest. The Beverley Company's reaper, which is propelled by three horses walking behind it, takes 7½ft. breadth at once, and delivers an admirably laid swathe to the right or left hand as desired. Hornsby and Sons' "Plymouth" reaper cut well, and laid a very uniform swathe. Bamlett's was remarkably successful. Burgess and Key's screw-platform reaper performed admirably, both in cutting and in delivering a well laid swathe ready and easy for the gatherer and the binder. In the second trial were Brigham and Bickerton's with revolving rakes; Walter A. Wood's American prairie machine, with a single rake to clear the platform by traversing horizontally upon an endless pitch chain, which is concealed in a groove surrounding the platform; Howard's "British" reaper, Samuelson's old pattern and new pattern machines, Burgess and Key's "M'Cormick" reaper, and Hornsby and Sons' "Governor" and "Progress" machines.

Hornsby's newest reaper, with shafts and with driver's seat on the pole, delivered remarkably regular, square-ended sheaf bunches. Howard's sheaves were also neatly laid, and the peculiar action of the gathering boards in entering the crop low down and then lifting the laid corn and laying it upon the platform in readiness for delivery by the rakes was much admired. Burgess and Key's sheaves were rather more spread, but the cutting beautifully done. Samuelson's new machine, in which the rakes rotate out of the way of the driver's seat at the side, made admirable sheaves and cut half an acre in twenty-six minutes. Among manual delivery machines, Bamlett's, with fixed as well as vibrating knives, made splendid cutting; Cuthbert's strongly-built machine did admirable work Picksley and Sims's extraordinarily compact piece of mechanism attracted considerable attention: Howard's machine displayed great capacity for following closely over all irregularities of the surface. Several other machines made excellent work.

The awards of prizes for the mowing machines and combined mowers and reapers, are as follows: Combined mowers and reapers, 1st prize £20, Messrs. Samuelson and Co., Banbury, Oxfordshire, for combined self-raking, reaping, and mowing machine (two horse); 2nd prize, £10, Richard Hornsby and Sons, Grantham, for new patent paragon combined mower and reaper. The judges were of opinion that all the machines exhibited under the title of one-horse mowers were far too heavy in draught to be worked by one horse, and therefore, under clause 3 of their instructions, withheld the sums assigned for prizes of this class. Prizes for mowers: 1st, £20, Messrs R. Hornsby for new patent paragon mower; 2nd, £17, W. A. Wood, London, for grass-mowing machine; 3rd, £13, Burgess and Key, Newgate-street, London, for mowing machines for two horses. The following are highly commended: Messrs. Samuelson and Co., Banbury, patent grass-mowing machine (two horse). Commended: Mr. A. C. Bamlett, Thirsk, for two-horse mower.

For reaping machines the results are as follows:—For machines delivering the cut corn in continuous swathe at one side, and clear of the horse track, a prize of £25 is given to Mr. A. C. Bamlett, £20 to Messrs. Burgess and Key, £15 to Messrs. Hornsby and Sons; and the Beverley Iron and Wagon Company obtain two commendations, one for their three-horse and another for their two-horse machine. For machines delivering the corn in sheaf bunches, Messrs. Hornsby and Sons take £25 and £20 for two "Governor" reapers, one a right-handed, the other a left-handed machine; Samuelson and Co. take £15 for their new self-raking machine; and another of Hornsby and Sons' "Governor" reapers and one of their "Progress" reapers are highly commended. For machines without self-delivery, or, in other words, manual-delivery machines, £12 are awarded to Messrs. Hornsby and Sons, £10 to A. C. Bamlett, and £8 to Samuelson and Co. For one-horse manual-delivery reapers, £12 are awarded to A. C. Bamlett. £10 to Hornsby and Co., £8 to Cuthbert and Co.; and Samuelson and Co. are highly commended.

Steam cultivating machinery was represented by Messrs. Fowler of Leeds, Messrs. Howard of Bedford, Mr. Fisken of Newcastle, and Messrs. Kinsey, Norton and Hill of Nottingham. Mr. Fisken has applied a modification of Mr. Ramsbottom's "flying rope" to steam cultivating purposes. In place of traversing his engines along the headland, as in the double engine system, or leading the wire rope round the field from an engine in a fixed position, as in the round-about system. Mr. Fisken employs a couple of windlasses, which are traversed along the opposite headlands, and drives these windlasses by means of a "flying rope" driven by the engine, which is placed in any convenient position. Mr. Fisken employs a Manilla rope, and the gearing of the windlasses is proportioned, so that the speed of the rope is about thirteen times the mean speed of the implement. With this latter moving at the rate of three miles per hour, therefore, the rope would travel at a speed at 3,432ft. per minute, and each 9·6lbs. of "pull" exerted upon it would represent the development of an effective horse-power by the engine. The rope is driven by passing it round the grooved fly-wheel of the engine, and the windlasses are fitted with gear which renders them self-moving. It is claimed for this system that the engine can be placed on hard ground wherever coal and and water can be most conveniently supplied to it, that the power can be transported long distances, and there is but slight strain on the anchorages of the pulleys round which the flying rope passes, and that the rope itself is of comparatively small cost. Mr. Fisken's system is being introduced by the Britannia Steam Cultivator Company, Leeds.

There were several traction engines and road rollers exhibited, such as Mr. Thomson's india-rubber tyre engine and pot boiler; also engines by Messrs. Clayton and Shuttleworth, Messrs. Aveling and Porter, Messrs. Robey, and Messrs. Garrett, which are all too well known to require any detailed description. Messrs. Manning, Wardle, and Co. exhibited a road roller constructed according to the design of MM. Gellerat & Cie., of Paris. It is 14 tons in weight, and is made to roll a width of 4ft. 6in., and is carried upon two rollers but 4ft. in diameter. The engine appears very top-heavy, the centre of gravity being much too high. Messrs. Aveling and Porter's roller, to which a silver medal has been awarded, weighs 15 tons empty, and a little over 16 tons in working order, and is carried on four broad wheels or rollers, two of these—the drivers—being placed near the front end, and the other two being arranged close together behind the fire-box, so that they cover the space left between the leading rollers, and, in fact, slightly lap the tracks of the latter. The leading rollers are 5ft., and the hind rollers 4ft. 9in. in diameter, and the total width rolled is 6ft. The driver stands on one side of the engine, and the steersman on the other, and the whole of the gearing is very simply arranged, and is fully open to inspection. To enable the roller to adjust itself to curved or uneven roads, the turntable to which the axis of the hind rollers is fixed is so arranged that the engine can, as it were, rock upon it to a certain extent, and one of the leading rollers can thus drop freely down to a lower level than that on the other side without disturbing the bearing of the hind rollers in any way. This roller did some good work at Manchester during the week preceding the show. On the first trial in Peter-street, 2,225 square yards of newly-metalled roads were rolled down in ten hours, with the consumption of 6 cwt. of coke, while on a subsequent occasion, when the machine was tested in front of the Town Hall, 600 square yards were rolled down in 2½ hours, the expenditure of fuel in this case being but three bushels of coke. In each case the machine was managed by two men. By placing spikes in holes provided for them in the wheels, Messrs. Aveling's roller can also be employed for picking up the road, and its capabilities in this respect were recently tested in Birmingham. On that occasion an area of 2,058 square yards was "picked up" in three hours forty minutes, 160lbs. of coke being burnt. The cross-picking was afterwards performed by hand labour, fourteen men being employed for 1¼ hours, thirteen men for 1½ hours, seven men for 2 hours, and three men for 3 hours—the whole being equivalent to one man working 60 hours.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON THE MONCRIEFF SYSTEM OF WORKING ARTILLERY AS APPLIED TO COAST DEFENCE.

By Captain Moncrieff.

Until the time of the Crimean war very little and very slow progress had been made in artillery. Cannon were manufactured on nearly the same models, and of the same materials that had been used for 300 years. Before that time cast-iron was not in use, but the forged or bronze guns, although in some cases large, were not what is now considered powerful; and the penetration of their shot was not sufficient to pass through a parapet of earth that is now pierced even by light rifled artillery. The conditions, therefore, under which artillery was worked, and the means provided for protection against its fire, remained much the same as they were in the time of Vauban. Several events during the Crimean campaign confirmed an impression that has always been more or less entertained, that an increase in the power of individual guns produced greater results than could be obtained by a much greater weight of metal, distributed among a larger number of small pieces of artillery. It is not too much to say, that the development of this art has, since 1855, changed the character of war both on land and water. It has established completely the superiority of a few large pieces over a much greater weight of metal in smaller guns. It has given artillery of all classes a range, penetration, and an accuracy of *Fire*, which throw into the shade the greatest results that had been previously obtained. It has also stimulated the advocates of cast-iron smooth bores to produce guns that might rival the rifled artillery; and yet it is by no means probable that the limit of power, either of large smooth-bores or rifled guns, has been arrived at. When it became apparent that mighty results were to be obtained from improved artillery, a great deal of engineering talent was directed to the subject. Comparatively new appliances, such as the steam-hammer, and new methods of working steel, were called to aid in the construction of the new and powerful guns. So much interest, indeed, was taken in the subject, and so much attention absorbed by it, that the conditions which these improvements in artillery themselves imported with them ran some danger of being neglected. The power of artillery became so great, that the ordinary provisions for protection against its fire were rendered useless. Forts that were considered strong twenty years ago would crumble under the shock of modern projectiles, and in some cases would even be too weak to support the guns while they were fired. That service which the new artillery affected most palpably was the Navy, and the Navy accordingly took the initiative in introducing means calculated to resist the penetration of the new and terrible projectiles. Every one is more or less conversant with the process that has been going on of covering ships' sides with iron, which has increased in thickness till it really looks as if the process at last would only be limited by a ship's power of flotation. War-ships, however, not only protect their sides against shot, but they also carry the heaviest artillery on their decks. This fact could not be overlooked by those who had to construct coast defences, as well as other works against which modern heavy artillery might be used.

I shall not enter into details regarding the successive steps which were taken in England in this direction, as I understand Colonel Jervoise has already done so in this Institution. It is enough to state that great engineering skill has been exercised, and unwearied efforts have been made to meet the new conditions. That skill and these efforts have, with the experiments at Shoeburyness, given us defensive iron structures which are marvels of strength and ingenuity. Unfortunately they are also marvels of costliness; and there is room to hope that their use will therefore be generally confined to such positions on *land* as can only be protected by such iron structures. This hope is founded on another system, with which my name is connected, and which I am here to explain. Before doing so I shall point out the dilemma which left military engineers no alternative, and which compelled them to give up in succession the use of earth, concrete, granite, &c., and at last to resort to the most expensive, but the strongest, material—*iron*.

There are two considerations always to be taken into account in providing the means of using artillery: the one is to place the gun so as to be most formidable to the enemy, and the other is to place it at the same time under as much cover as possible, so that it is not liable to be disabled, nor are the men serving it liable to be destroyed by hostile fire. These two conditions interfere with one another; that is to say, whatever has hitherto been gained in one direction has been lost in the other. Guns, *en barbette*, lack protection; guns in embrasures or in casemates sacrifice, on the other hand, free lateral range, and it is more difficult in their case to see the enemy, and therefore to lay the guns in action. The difficulty that presented itself with the introduction of late improvements in artillery was simply that the increased precision and range, coupled with great improvements in the manufacture of large shells and also in small arms, rendered barbette batteries too exposed to be relied on. At the same time the tremendous penetration and precision of the new artillery rendered the ordinary parapet and embrasures useless. What was to be done under these circumstances? Protection from direct fire must be got at any price. The first impulse would be, to thicken the parapet. This could not, however, be done, as the necessary angle in the cheeks of the embrasures required for training the guns opens up a wider aperture, in direct proportion to the thickness of the parapet, making the *maximum* thickness in practice 30ft. But shot have been known to penetrate more than 30ft. into the earth; and the most important part of the parapet, *viz.* that near the guns, must always be thin and weak, whatever may be the thickness of the rest. Shells, striking this part, would just meet sufficient resistance to burst them, and would make havoc among the men. Next, granite masonry was thought of; but it proved in some respects worse than earth, and was found practically bad; there was no alternative but to go to iron. This conclusion was reluctantly arrived at, and reluctantly it was acted on.

The decisions of committees which investigated all the bearings of the question, the opinions of professional men, and the experiences of the American war, all coincided, and accordingly our important coast-works were designed to receive *iron* shields, casemates, and cupolas. Vital positions in England, such as dockyards and arsenals, must be fortified. It would be false economy indeed to use any method of fortification that experience has proved to be insufficient. *No savings* could justify the erection of works that might prove at once the tomb of their defenders and perhaps of the nation's honour. Therefore the only proper decision was, to take that means to meet the difficulty which was at the time considered best and safest. Expense was properly a consideration very secondary in importance to efficiency.

I shall now endeavour to point out the difficulty of the task which lay before the engineer, even after the decision in favour of iron, from the extraordinary advances, already spoken of, in artillery. There is only one morsel of comfort left for those who have to provide for the requirements of defence, viz., that a form of artillery-fire of a very galling nature remains exactly as before, and indeed is not much better than it was in the time of Queen Elizabeth. What is alluded to is vertical, or mortar fire. There is some consolation, too, in the reflection that the cause of this fire not being much improved is one to a great extent likely to be lasting. Rifled mortars would no doubt lessen deflection to right or left; but as long as gunpowder is affected in strength by the slightest atmospheric or other influence, and still more certainly as long as a slight error in elevation at long ranges will make a large error on the plane of fire, the comparative inaccuracy of vertical fire must continue. To show how little can be done in this way compared with the admirable precision and accuracy of direct fire, I may state that 100 rounds were fired one day last season at Shoeburyness at 800 yards range with a 13in. mortar at the row of experimental casemates which cover a good deal of ground. The mortar was laid with spirit-levels and all the appliances of the school of gunnery, and yet the 100 rounds were expended without a single hit. If such is the case with a steady platform and under such exceptionally favourable circumstances, it can easily be seen how uncertain in its effects would practice be from mortar-boats, which move with every wave, if directed at an equally small object. During the eleven months' siege of Sevastopol the French had 242 mortars engaged, which were themselves exposed to vertical fire, and yet not one of these mortars was disabled. It is indeed a strange contrast, that while direct fire is getting more powerful, more accurate, and more destructive every year, vertical fire remains much as it was, and can only be relied on to hit a large object, such as a fort, a town, or anything that covers a great deal of ground. Notwithstanding this, it would be a great mistake to despise it as a powerful and galling means of attack.

To return to the difficulties of meeting direct fire in coast defence. It must be borne in mind that batteries intended to engage ships are obliged to meet an enemy who can move his position to that quarter where he is least exposed, who can continue in motion while he is conducting his attack, and who can seek out the most vulnerable face of the land-work to operate upon. In constructing such batteries it is first of all necessary to make them of sufficient strength to resist the guns of ships which are the most powerful that can be made. It is next required that these batteries should be constructed in such a manner that they can direct their fire with rapidity and precision in any direction in which the ships can take up their position. And lastly, it is required that they should mount guns of sufficient weight and power to be formidable to the heaviest iron-clads.

In former times guns *en barbette* were preferred for this purpose, because they met the two first requirements alluded to; that is to say, that from not being confined by embrasures or ports, they were able freely to follow their floating enemy whatever position he might take up, naval fire at that time being neither so correct nor so formidable as to make such batteries unserviceable. The case, however, is now completely changed; for not only have guns been improved, but ammunition also; and heavy shells are most destructive. Rear-Admiral Porter, of the United States Navy, in a report on coast defences, says, "Such guns, *standing so high up*, are just the objects that navel gunners would delight to explode their Shrapnell against, and from my experience in naval gunnery, the third shell would kill every man at the gun." Von Scheliha, in his treatise on coast defences, "Guns mounted *en barbette* may always be silenced by an iron-clad." This form of battery, therefore, is disposed of. We shall now examine the difficulties connected with the other alternatives. Common masonry batteries have been condemned as worse than useless, as they would only make the ship's fire more destructive than if directed against guns *en barbette*.

Next comes the expensive alternative which has been adopted, viz., iron shields, casemates, and turrets. It is most interesting to examine how far this system of iron, the last alternative left, meets the three requirements of coast defence alluded to, and to see what very great difficulties had to be encountered in applying it.

The three requirements are thus recapitulated:—1st. Strength of the battery to resist naval fire, and give sufficient protection to the men. 2nd. Power of fighting the guns with accuracy and effect, of following the enemy with ease as he moves, of being able to face him on any side from which he approaches. 3rd. Power of using the most formidable guns to advantage.

The first difficulty was to decide the matter of strength. Now guns are becoming more and more weighty and powerful every day, and therefore the strength required to resist them is an unknown quantity. An iron casemate of the present proposed strength costs, according to official returns, with all the battery adjuncts except the gun and carriage, about £5,000 or £6,000 for each gun. A 2-gun turret, about £25,000 or £30,000.* If guns of 50 tons are introduced in ships, as is proposed, these defences are at once quite inefficient, and it is not known how strong or how expensive should be the iron works to replace them. Such questions must be very embarrassing indeed to those who have to decide these matters. Besides protecting the gun and carriage from the enemy's shot, protection must also be given to the men. This is the most serious of all considerations in coast defence, for the following reasons:—The best experience we have regarding naval attacks on land-works is derived from the late American war, in which a great many actions of that kind took place. It would be unwise to ignore this experience, because the increasing power of artillery only gives it more weight. During the whole of that war very few guns were destroyed by the naval fire in earthen batteries. At Fort Wagner only three guns were totally dismounted, although 2,864 shot and shell were fired into it in forty-eight hours, and the bomb-proofs were hit 1,200 times. Seventeen siege-mortars, several cohorns, and thirteen heavy pieces of artillery were incessantly employed. At Fort Fisher the bombardment was opened at the rate of 115 shells per minute, and although the guns were mounted *en barbette*, only two of them were dismounted when the place fell. At Fort Powell a tremendous bombardment from mortar and gunboats (the most accurate firing being from 15-inch mortars) was maintained from 22nd of February till 2nd of March, and not a single gun was dismounted. The success of the ships over the forts was gained by demolishing the works, and still oftener by making the service of the guns so dangerous that the men could not work them.

Rear-Admiral Porter, U. S. Navy, in his report on coast defence, states, "The new-fashioned casemates turned out to be no better than the guns *en barbette*. They were perfect slaughter-houses, and were piled up with dead and wounded. Every shell that went through the port-holes killed and wounded every man in the close casemate. This proved to me most satisfactorily that guns in casemates were no better protected from shells than those *en barbette*."

With such evidence as this before them, from men who were conversant with all the events of that great war, it was indeed a serious question to decide what was to be done. I myself cannot see how men in an iron casemate are as much exposed as in a barbette battery; but there is no doubt that if the port of the strongest casemate was as large as those referred to by Admiral Porter, it would be open in the same circumstances to the same dangers as the damage was done by entrance of shell through the port. The protection a casemate would afford from vertical fire in such a case would be but a poor advantage if more correct and more deadly weapons than the mediæval mortar could still search out at times the exposed point of the casemate and kill every man inside. The next requirements in a coast battery, viz., to be able to follow an enemy amidst clouds of smoke, and to lay the guns on him with precision and dispatch, formed a more embarrassing difficulty still. On the one hand, the ports must be constructed for muzzle-pivoters to give protection. On the other hand, if they are made so small it is difficult to see through them, to fire correctly and quickly at different elevations, and on different sides on a moving enemy. The battery is in the position of a knight who must either expose his vitals to his enemy's lance or put on armour that paralyzes his sword arm. There is as much protection in the power of being able to strike as there is in being able to guard. As naval actions are likely to be short and decisive, it must have appeared extremely doubtful whether it was worth purchasing increased safety at the expence of losing the attacking power. The last of the three requirements in coast defence stated was the necessity of using the most powerful cannon. This did not present the same difficulty as the other two, because the designers of our defences had been presented by my friend Captain Coles with the means of mounting the heaviest guns to fire in any required direction. When very large and valuable guns are used, it is not advisable to cramp their action and restrict it to a small area. The turret was therefore preferred to the casemate when lateral range was require; and though apparently very expensive it was in reality cheaper than casemates, because, although the mounting of the guns in this manner cost more, they were enabled to do much more work, and there was thus an economy both of guns and men.

Having thus far endeavoured to describe the extraordinary difficulties which the new improvements in artillery inevitably entailed on the engineers, I shall now direct your attention for a short time to the difficulties in which the same improvements involved the artillery-men themselves. These difficulties, though not quite so important as the engineering ones, were very serious indeed, and have not yet been quite overcome. They consisted chiefly in the difficulty of making carriages and platforms strong enough for the new and powerful rifled guns. These pieces burnt enormous charges of powder, and hurled bolts as heavy as an old field-piece at 1,000ft. a-second. The recoil of such guns represents a violence of force the like of which man has never had to deal with before. Imagine 12, 18, or 25 tons of compact iron started in an instant into rapid motion with a violence that mocks the blow of a steam-hammer. This force has to be controlled and restrained. It is no wonder then that, when met directly and stopped by friction, as is now done in the ordinary system, the difficulties are enormous. The horizontal strain on the platforms, pivots, and racers, is so great that it has not yet been quite successfully met; constant changes and inventions are being made to render this force more harmless.

I hope I have now conveyed to your minds some idea of the embarrassment and difficulties which have fallen upon both the artillery and engineers by the rapid improvement of these formidable engines of war; and of the persistent able struggle which both have maintained to meet directly the terrible forces with which they have to contend. They have both succeeded to a wonderful extent, but their success is blighted by that curse of the science they practise; the law that up to this time has existed—viz., that what was gained in protection was lost in efficiency, and the converse. Happily I had the good fortune to conceive and develope an idea which abrogates this law. The very force the existence of which has been so great a difficulty in the artillery question has been compelled to perform a service that at once sweeps out of existence a great many of those other difficulties that embarrassed fortification. When two evils coexist, it is sometimes good policy to make them destroy each other.

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* The price of a permanent Moncrieff battery, with magazines, &c., including the extra expense of carriages, is from £1,100 to £1,500 for each gun; an iron shield battery from £1,800 to £2,000 per gun; an iron casemate battery, from £5,000 to £6000 per gun; a turret, from £12,500 to £15,000 per gun.

I shall now refer shortly to the train of ideas that led me to think of solving the important problem in quite a different manner from that in which it had been attempted, which had led to the adoption of a most expensive class of works. My solution gives a system capable of mounting the heaviest artillery, while it simplifies the vexed question of fortification. It gives protection without the expense of using iron, and free lateral range to the guns without exposure. The system is indeed a simple one; it does not require either brute strength or heavy expenditure for its application; nor does it need mighty forges to weld iron walls to protect our guns and gunners; it only calls to our aid the simplest and most docile forces of nature. Instead of trying to meet force by force, I make my guns bow to the inevitable conditions which science has imposed; and instead of wasting energy, money, and skill in attempts to raise a buttress against the new artillery, I employ the hitherto destructive force of recoil to lower the gun below the natural surface of the ground, where it can be loaded and worked in security and in comfort; and at the same time, I have made that destructive force so much my servant that I compel it at my pleasure to raise the gun again into the fighting position whenever it is required. In 1855, while watching the interesting operations before Sevastopol, and endeavouring, as well I could, to understand the conditions under which the siege-artillery was used, I conceived the idea which is now realized. It was then that I saw the value of earth and the importance of simple expedients. It was plain that the weak point of a battery was the embrasure, which formed a mark to fire at, an opening to admit the enemy's shot, and required constant repair even from the effects of its own gun, which in firing injured the revetments of the cheeks. I also came to the conclusion in my own mind that a remedy for some of these defects could be devised. Afterwards I worked at various plans, of which sketches were made or models; but each design had defects which discovered themselves to me as my experience increased. The real difficulty of the thing arose from the necessity of providing for the enormous strain of the recoil. These early designs, which were sometimes excellent in other respects, broke down at this difficulty, and although some of them no doubt would answer with small guns. they were not calculated to meet the tremendous recoil of large rifled pieces.

At last I hit on a simple principle that would meet this difficulty to advantage—the interposition of a moving fulcrum between the gun and platform. Then I knew that the problem could be solved; and feeling the great importance of the subject, I resolved to devote my efforts to working it out completely. While directing my attention to this simple and then apparently obscure matter, I was, as you may imagine, neither an idle nor disinterested watcher of the progress of artillery. Every step in advance was riveting the certainty in my mind that the system would one day be required, and with this conviction I refused to allow either discouragement or delay to make me desist. I shall now endeavour to explain shortly the system which bears my name, as far as it relates to coast defence.

It consists of three parts:—1st. The mechanical principle of the gun carriages. 2nd. The form internal and external of the batteries. 3rd. The selection of ground for placing the batteries, and the arrangement for working them to the greatest effect; or in other words, the *tactics* of defence for positions where the system is employed. The principle on which the carrige is constructed is the first and most important part of the new system, because on it depends the possibility of applying the other parts. This principle may be shortly stated as that of utilizing the force of the recoil in order to lower the whole gun below the level of the crest of the parapet so that it can be loaded out of sight and out of exposure, while retaining enough of the force above referred to bring the gun up again into the firing or fighting position. This principle belongs to all the carriages; but the forms of these carriages, as well as the method in which this principle is applied, vary in each case. For instance, in siege-guns, where weight is an element of importance, the recoil is not met by counterpoise. With heavy garrison guns, on the other hand, which when once mounted remain permanent in their positions, there is no objection to weight. In that case, therefore, the force of gravity is used to stop the recoil, because it is a force always the same, easily managed, and not likely to go wrong; and as these carriages are employed for the most powerful guns, it is a great advantage to have the most simple means of working them.

It has been already mentioned that the principal difficulty arose from the enormous and hitherto destructive force of the recoil of powerful guns; and here I shall point out the manner in which that difficulty is overcome. That part of the carriage which is called the elevator may be spoken of and treated as a lever; this lever has the gun-carriage axle at the end of the power-arm, and the centre of gravity of the counter-weight at the end of the weight-arm, there being between them a moving fulcrum. When the gun is in the firing position the fulcrum on which this lever rests is almost coincident with the centre of gravity of the counter-weight, and when the gun is fired the elevators roll on the platform, and consequently the fulcrum, or point of support, travels away from the end of the weight-arm towards the end of the power-arm, or in other words it passes from the counter-weight towards the gun. Notice the important result of this arrangement. When the gun is fired its axle passes backwards on the upper or flat part of a cycloid. It is free to recoil, and no strain is put upon any part of the structure, because the counter-weight commences its motion at a very low velocity. As the recoil goes on, however, the case changes completely, for the moving fulcrum travels towards the gun, making the weight-arm longer and longer every inch it travels. Thus the resistance to the recoil, least at first, goes on in an increasing progression as the gun descends, and at the end of the recoil it is seized by a self-acting pawl or clutch. The recoil takes place without any jar, without any sudden strain, and its force is retained under the control of the detachment to bring up the gun to the firing position at any moment they may choose to release it. The recoil moreover, however violent at first, does not put injurious horizontal strain on the platform. In my experiments at Edinburgh with a 32-pounder, I found that so slight was the vibration on the platform caused by firing that the common rails on which the elevators rolled in that experiment, and which were only secured in the slightest manner, did not move from their position, nor even when heavy charges or double shot were used, did sand and dust fall off their curved tops.

At a still earlier experiment made with a model of a 95-cwt. gun, the model was fired on the ice with excessive charges, and nevertheless remained stationary. This valuable concomitant of the system cannot be appreciated fully without referring to the difficulties that have been experienced, and are now felt, in getting pivots, platforms, &c., on the ordinary system strong enough to mount the new artillery, where the recoil is stopped by friction applied directly by means of what are technically called *compressors* attached to the platform.

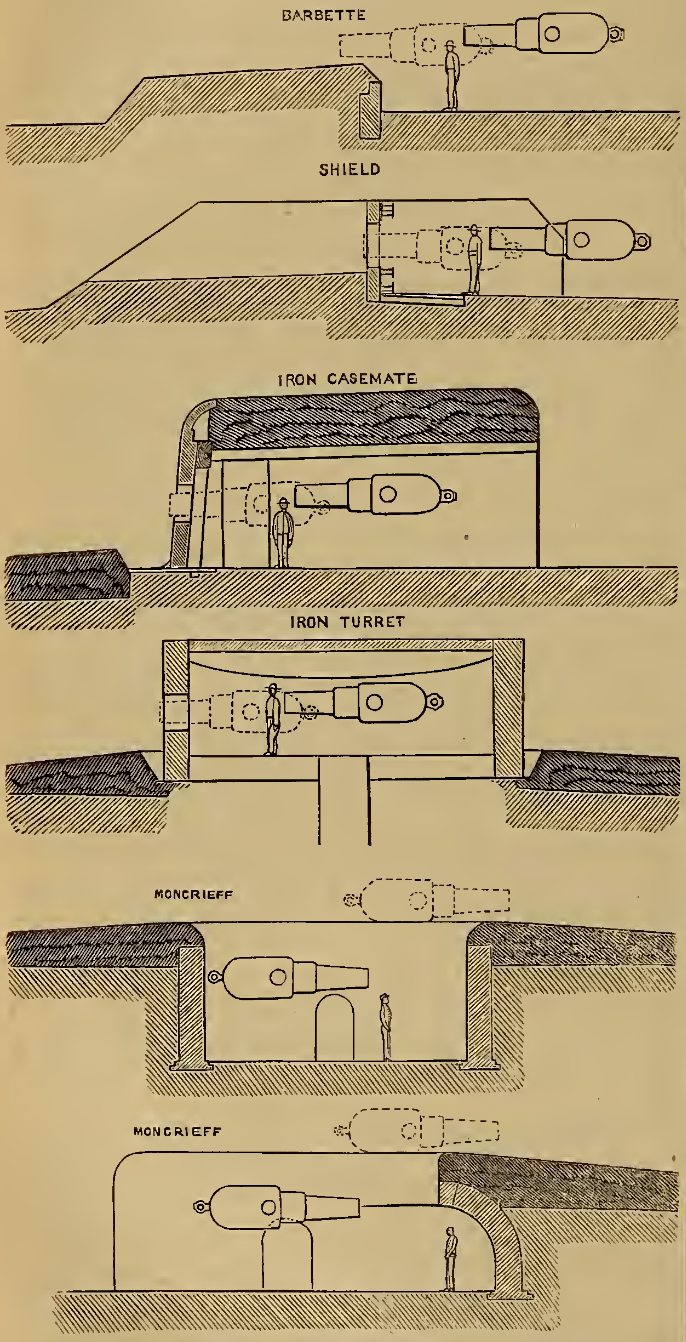
I shall not detain you by detailing these difficulties, but will only state that the first two 12-ton guns on ordinary carriages that were fired in casemates (which happened a few months ago) at Gilkicker Fort were both *hors de combat* the first shot. This alarming event showed that with all the experience of ancient and modern artillery (and the carriages referred to were the legitimate exponents of the results of that experience), there was still room to doubt whether the problem of meeting recoil had been at that time completely solved by the existing system. The accident referred to was serious, because it might occur in action, and in that event would disable the gun, *pro tempore*, as completely as if it had been dismounted by a shot. Some credit may be claimed for the new system, on the ground that it provided a carriage for a heavy piece of artillery on an entirely new principle, in which not a single part was copied from anything that had been formerly used, dealing with new conditions and performing new functions that no other carriage had done, and yet this new carriage (the first complete one of its kind) has now fired *two hundred rounds.* This practice has been carried out with only a few accidents which pointed to defects in the gearing, which were easily remedied. By treating this violent force in the manner above described, a good deal of the strength that is required in other systems becomes unnecessary, and at the same time the recoil, however violent, can not only be met, but utilized. Together with the carriages there are some improvements of minor importance, such as trunnion pointers, reflecting sights, graduated races, and so on, which it would be out of place to discuss at present, but which contribute to the efficiency and completeness of the system, and are more or less required for carring it out as a consistent whole for coast defence.

The second part of the system, viz., the profile of the batteries, is of the highest importance, because unless it is attended to great advantages are lost. This, unfortunately, makes the system extremely difficult of adaptation to existing works. In order to get the full advantage of it no exterior slope of parapet should be exposed to the view of the enemy. This, prevents him from being able to tell whether the fire be correct or wasted, and affords no means to him of correcting error. The battery in fact is masked; so that at some distance, or in dull weather, a moving ship would have considerable difficultry in laying her guns on one battery, and still more difficulty if there were several batteries judiciously placed for the purpose of deceiving the eye. It can easily be understood that the slightest error in elevation would either carry the shot harmlessly over the battery or else cause it to ricochet off the glacis or superior slope. In fact when the gun is down the enemy has nothing to aim at but an undefined horizontal line. In connection with this I should mention a very interesting fact, brought out by Genenal Simmons at the last discussion of the Royal Engineers on a paper of mine. He stated that on analyzing the range reports of the Armstrong and Whitworth competitive trials, which were very carefully conducted, he found that the mean horizontal and vertical errors were very different. The horizontal error increased almost directly as the range, that is to say, at 400 yards it was four times as great as at 100 yards, but that the vertical error went on in a rapidly increasing progression, showing that it would be much more difficult to hit a low object than a high one of the same area. This law has an important bearing on the subject, and should not be lost sight of in designing defensive works of any kind. It will be observed that the interior slope of the parapet gives the most complete protection to the men, especially when the dome-form is adopted.

Up to the present time the new system has only been considered as an improvement, and its value has only been estimated as an adaptation to existing forts, and there are no proposals for applying it *per se.* I am extremely anxious to impress on you and on my countrymen that its full value cannot be seen in this manner, and that it suffers injustice by being thus treated. I trust its proper use will be fully discovered before the inevitable lesson is dictated by was, and that it may be applied in works expressly designed for it, and not merely adapted to its use.

The third part of this system consists in its application to given positions, the disposition of the batteries, and methods of working them in concert with or in support of each other. If I might be excused for using the paradox, the system for coast defence consists in the absence of any defined system; that is to say, instead of making large regular forts, and forcing surrounding circumstances into harmony with them, every accident of the ground in this case would be seized, where available, and small batteries, consisting of a few guns, or even one powerful gun, laid down so as not to take away the natural aspect of the position. These batteries would be well retired from the channel, and placed so as to support each other in case of attack, and should, when circumstances permit, afford flank defence to each other, in conjunction with obstacles of any character that could be conveniently employed, and with strongholds for infantry and light artillery, commanding, if possible, the sea-batteries, so as to make them untenable by an enemy, and so placed as to be in the best position for a reserve, ready to support any point attacked; the whole connected with good and sheltered roads. In stopping the passage of a navigable river or channel, for instance, the guns, instead of being massed, would be scattered round the points where marine obstructions were placed. These guns would be disposed in such a manner as to retain as much as possible for the defence the advantages of a free lateral range, converging fire and different amounts of command. In other words, the method consists in placing in position the heaviest and most powerful artillery to the greatest advantage, making that the first consideration, and afterwards protecting the batteries, by separate and distinct arrangements easily devised by officers on the spot, against assault by any force that ships might land for that purpose. When an object is to be attained, I prefer to grapple with the most difficult and important part of it first,—do that well,—and meet the other requirements afterwards, with as little loss of efficiency as possible.

*Sketch shewing in section specimens of five methods of mounting heavy Coast Artillery.*



The first object of coast defence is to meet and defeat the attack of powerful ships; the next is to protect the shore-batteries against landing parties. It must not, however, be forgotten that there are positions of such importance that they might be attacked by an army on land. Such positions must either be defended by another army placed in a favourable position by such arrangements as those above referred to, or else by regular and complete earthworks thrown up in time of danger, which would enable a still smaller garrison to resist anything but regular approaches. There are, however, few coast positions of such importance as to draw the attack of a whole army; and such positions, as a rule are now provided with regular works of a very order; whereas there are many positions exposed to a naval attack, such as our large mercantile ports, &c. They are almost invariably centres of population, who require only fieldworks and good small arms (which are now more powerful than ever) to repel the most determined attacks of any numbers that war-ships could land. I believe many of the *present* coast-works are defensible only against a *coup de main*. Wherever land attack is of more importance than naval, the character and efficiency of sea-batteries must give precedence to those considerations which provide against assault. On the best provisions for meeting this I do not pretend to give an opinion. In such cases, the possibility of attack by both direct and vertical fire must be kept in view. Where my system is employed for arming such works, one or two precautions would increase the power of resistance. 1st. The large guns for operating against ships, with traverses and *parados* to each, should be kept as far as apart as space will admit. 2nd. Ample and thoroughly complete bomb-proof cover for the whole garrison should, if possible, be supplied in the middle of the work, with arrangements for interior defence (not barracks but places for emergency) thoroughly secure from vertical fire—good and healthy barracks for the men being made independent of the works, and by preference kept out of the way. 3rd. Howitzers and light artillery ought to be kept in reserve, in bomb-proofs constructed for the purpose, and (with the new system this can easily be done) also with the means of changing these to any required face.

The dispositions of defensive batteries such as those I have very imperfectly attempted to describe would not be complete without good arrangements for internal communications, not only by roads, but by telegraph, with a clearly laid down and simple method of working them; that is, not liable easily to go wrong, nor to lead to mistakes, and which would not require very high skill. Such arrangements would increase the power of the defence, and indeed would be necessary with the detached system. I have accordingly given them some attention, and designed a general plan of laying off the ranges and working the telegraphs, which will make it possible to supply simultaneous information. The system I refer to (which has been submitted to the Director-General of Ordnance) would apply to any position, but its particular application would vary in each case. It is extremely simple. One part of it depends on electrical instruments which I have invented for the purpose, and which, without either calculations or experience, give the range and positions of an indicated ship at every gun in the position.

Another part of it enables the officer directing the defence to deliver in one instant, by the touch of his finger a converging volley from one or both sides of a channel on a vessel sailing past. The possibility of delivering correct fire in this manner on a moving object, without aiming, and by an officer not even in the battery, was illustrated in one of my experiments with the 7-ton gun-carriage at Shoeburyness; and I trust I may be given some day a chance of showing to what perfection this system can be carried. Methods of determining the distance of vessels from batteries are practised here and in some continental countries. My method is designed to be quicker, simpler, and therefore more effective. It is adapted to work in conjunction with the arrangements for submarine mines. That part of it which gives the required information for sighting the guns is of so simple a character, that the most uneducated gunner cannot make a mistake in its application. There are many other features of the system besides those I have particularly referred to which I shall not now discuss; each requires different treatment. Among these there are methods of mounting guns in ships, in floating-batteries, Moncrieff-carriages for heavy guns of position, adapted for locomotion, for coast-defence, siege-carriages, &c.

I may remark in passing that some of these applications are considered by officers of eminence to be quite as important as the class of Moncrieff-carriages best known. For instance, I take the liberty of quoting from a letter I received from Colonel Brialmont, the great Belgian engineer and military writer, in November, 1868. He says:—"I am at present engaged in publishing a great work on fortifications. I shall naturally speak of your invention in it, and if agreeable to you I shall likewise mention your proposal with regard to *barbette* system in batteries of attack. I believe this idea is destined to have a great future. This last invention will perhaps bring you less renown than the one you have experimented on at Shoeburyness, but it will have a more general and easier application."

I am most anxious to impress the national importance of this question of coast defence in relation to the system of earthworks which are now possible. The day has gone by when the general principles of any science need be considered a mystery, and I submit that any man of intelligence, without knowing all those details which are the particular business of officers trained to apply them, may nevertheless form valuable opinions on the general principles of coast defence, and may, with care and observation, be able to arrive at sound conclusions regarding them. The security of a country like this does not depend so much on fortresses as on the efforts that can be made by a contented, brave, and patriotic people. If it is known by those who would invade us that we have not only brave hearts, skilled hands, and powerful guns, but a system of applying our resources that is capable of making any coast position formidable to war-ships, that knowledge will have its effect. In war-time a good general disposes of his forces in that manner which will be most embarrassing and most formidable to the enemy. In time of peace we might arrange and prepare our coast defences on similar principles. The improved artillery applied in earthworks made thoroughly efficient on the new system, together with the facilities which the existing network of railways slightly extended would supply, should be made to go some way in meeting the corresponding advantages, that have been conferred on the power of attack by steam navies and iron-clad war-ships. If my labours have in any degree the effect of diverting the great resources of this country from a more expensive to a cheaper and more efficient system of coast defence both in the colonies and at home, and if thereby the security from outrage and disaster is increased, the consciousness of having helped to do so will itself be to me a reward for the delays, anxieties, and trouble that it has cost me to bring this matter forward.

# ON CHEMICAL CONSTITUTION, AND ITS RELATION TO PHYSICAL AND PHYSIOLOGICAL PROPERTIES.

By Dr. A. Crum Brown, F.R.S.E.

Chemists have long endeavoured to answer the question, what is the relation in which the constituents stand to one another in a compound? and numerous hypotheses more or less ingenious have been devised for this purpose. Two of these modes of representing chemical phenomena occupy so prominent a place in the history of the science as to merit special notice, even in so slight and hurried a sketch as this must be. These are, first, the electro-chemical and radical theory; and second, the theory of atomicity and chemical structure.

The first was the product of the genius, learning, and laborious research of Berzelins; it was soon adopted by all chemists, and formed for many years the foundation of all chemical teaching and the guide in all chemical work. The point of view from which it regards chemical phenomena is that of combination and decomposition, of the union of elements to form compounds and the separation of compounds into elements. A very important form of chemical decomposition is electrolysis, or the breaking up of a compound by means of current electricity. From the nature of the case electrolysis gives rise to a dichotomous decomposition, and this duality was extended to all cases of combination and decomposition. Elements combine with each other in pairs; these pairs may again combine in pairs, forming compounds of the second order, and so on. Thus calcium combines with oxygen to form lime, sulphur combines with oxygen to form sulphuric acid, and sulphuric acid combines with lime to form sulphate of lime. This union of compounds with compounds was not supposed to depend on a union of the constituents of the one with the constituents of the other, but to be a combination of the one as a whole with the other as a whole; not a combination of the calcium of the lime with the sulphur or with the oxygen of the sulphuric acid, or of the sulphur of the sulphuric acid with the oxygen of the lime, but of the lime as such with the sulphuric acid as such.

This view may be illustrated by a reference to the relations of human life. Individuals unite to form partnerships or corporations, and these may again enter into alliances, although the members of the one allied corporation may be altogether unacquainted and unconnected with the members of the other.

But the progress of discovery brought to light facts which seemed to contradict this view of binary combination. Cases were observed in which a compound of two elements united directly with an element, and to meet this new class of facts the theory was modified by the introduction of the notion of radicals. A radical was a compound which acts like an element.

The simile introduced above may be used to illustrate this extension of the theory. Some combinations of men (corporations) can be treated as individuals, can enter into legal relations with individuals, while other cannot; so some compounds can unite with elements, while others have not this capability.

The theory of atomicity regards chemical phenomena from an altogether different point of view. In it the various substances are considered as modifications of one another rather than as compounds. The rise of this mode of viewing chemical phenomena may be traced from the early papers by Dumas, and by Laurent, on substitution. It appears more prominently in the position given to double decomposition as the representative of all chemical action, by Laurent and Gerhardt, in the types of Gerhardt and Williamson, in Franklaud's theory of the organo-metallic bodies, and in its extension by Kolbe to the compounds of carbon. It was reserved, however, for Kekulé to combine these ideas into a consistent theory.[*] The theory has been further elaborated by Butlerow, to whom we owe the name "Chemical Structure," by Erlenmeyer, and by many others, and it has been adopted and applied with slight modifications by almost all chemists engaged in organic research.

According to this theory the typical form of chemical action is what we may call the *chemical exchange*. To illustrate this idea we may consider the simplest case; that of double decomposition where two molecules act on one another to produce two new molecules.

Chloride of sodium, for instance, acts on nitrate of silver, producing chloride of silver and nitrate of sodium. Comparing chloride of sodium and chloride of silver, we at once see that while there are important respects in which the sodium and the silver differ as to the nature of their unions with chlorine (thus the amount of work required to separate the metal from the chlorine is very different in the two cases) still, from one point of view (and that is the point of view taken by the atomicity theory), the silver may be said to replace or to be substituted for the sodium. In the same way a cup filled with mercury is very different from the same cup filled with water; and the relation of the mercury to the cup differs in many respects (such as pressure and adhesion) from the relation of the water to the cup; but they agree in this, that the cup is filled in both case. In the same way the chlorine is said to be saturated by the sodium or the silver, although the intimacy or firmness of the combination is not the same in the two cases.

We may also consider this double decomposition from the other side. As the silver and sodium have changed places, so the chlorine has changed places with the rest of the nitrate of silver—with what in the nitrate of silver is not silver; or representing the action in symbols ($NaCl + AgNO_3 = AgCl + NaNO_3$) Cl and $NO_3$ have changed places.

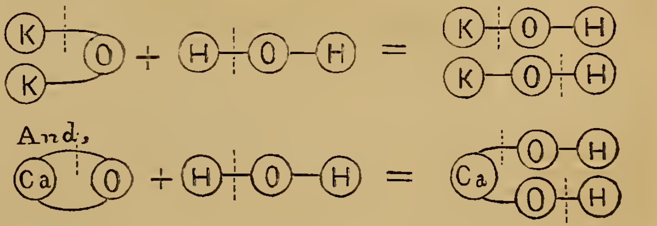
In this example we have one atom or group replacing one other atom or group; but all cases of double decomposition are not of so simple a kind. Thus, when water is treated with pentachloride of phosphorus we find that one atom of oxygen (from the water) replaces, and is replaced by, two atoms of chlorine from the pentachloride; thus, $PCl_5 + H_2O = PCl_3O + 2HCl$. So that while the two atoms of hydrogen were formerly united to one atom of oxygen and formed with it one molecule, they are, after the change, each united to a separate atom of chlorine and form with them two molecules.

Oxygen, therefore, in this case (and, as far as we know, in all cases) enters into two relations, while hydrogen, chlorine, silver, and sodium only enter into one. In a similar way it has been shown that the different elements have different "atomicities" or enter into different numbers of relations. It is to this "polyatomicity," or multiple-relatedness, that the complexity of compounds is due; for it is obvious that by the union together of several multiple-related atoms a very complicated structure may be produced.

In the case of a compound containing only two atoms, such as chloride of sodium, there is clearly only one way in which it can break into residues; but a complex substance containing many atoms may, and generally does, break in different ways when acted on by different substances; and it is by the study of the ways in which by means of double decomposition it can be produced, that we arrive at a knowledge of its structure, that is, of the mutual relation of its atoms.

But the multiple-relatedness of some atoms produces a further complication, producing a kind of chemical action, which, while still a chemical exchange, cannot be called double decomposition. In double decompostion we saw that each molecule breaks into residues which change places with the residues of the other molecule, and that this breaking into residues results from the rupture of one or more relations between pairs of atoms. But where we have multiple-related atoms, it may happen that such a rupture takes place without a separation of the residues, these being retained in combination by some other relation of their multiple-related atoms. To illustrate this we may compare the action of anhydrous potash, $K_2O$, and of anhydrous lime, CaO, on water.

Using graphic formulæ, we have in these two cases:—



Here the dotted lines indicate the relations ruptured; and it will be seen that, while in the first case the rupture produces a separation into two residues, in the second case it does not; what would otherwise be residues remaining united, on account of the double-relatedness of the calcium atom.

From this examination of chemical exchange, it will be obvious that no operation of this kind can produce a change in the "atomicity" of an atom; for, for every relation ruptured, a new one is entered into. But we have no reason to suppose that all chemical action is of this kind; and there are numerous phenomena which it is very difficult to explain, except by the assumption that there is another kind of chemical action, in which the number of relations of an atom is increased or diminished. Such actions are those by which we pass from one series of compounds to another. Thus the ferrous salts are connected together by processes of exchange; but it is only by making new hypotheses that we can thus explain the passage from the ferrous to the ferric salts. Similar relations exist between the manganous salts, the manganic salts, the maganates, and the permanganates, where a consideration of each group, apart from the others, would lead us to a different atomicity for manganese; and many other examples might be given of the same kind. The speaker considered it, in the mean time, to be better to regard each such series separately, rather than, by an attempt to bring all chemical processes under one class, to endanger the stability of the theory of chemical structure which, while it is probably not destined, in its present form, to remain as a permanent part of the great edifice of the science, is certainly a most convenient scaffolding, not easy to replace, and not hastily to be thrown down.

Having thus seen what is meant by chemical structure, and how we arrive at a knowledge of it by a study of the history of the substance, of the ways in which it may be formed and in which it may be decomposed; we may now glance at the relations which exist between the chemical structure of a substance and its physical and physiological properties. We shall consider specially two of the physical characters of matter, volatility and colour, and examine in what way these are modified by the performance upon the substance of certain specified chemical operations. The volatility of a substance depends upon two things:—1st, the temperature at which the substance boils under a particular pressure; and, 2nd, the change of boiling-point produced by a change of pressure. In order, therefore, fully to know the volatility of a substance, its boiling-point must be determined through a very great range of pressure. This involves great labour; and only a few substances have been thus fully examined. Almost all we know on this interesting question is due to the ingenious and patient experiments of Regnault. These do not, as yet, furnish us with sufficient data to enable us to deduce anything like a law. They show us, however, that a mere comparison of boiling-points under an arbitrarily-selected pressure (such as 760 millimetres, which happens to be the mean pressure of the atmosphere) cannot lead us to a law, as the boiling-points of two substances are frequently changed very unequally by a change of pressure.

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[*] It is right to observe that although Kekulé has used this theory with the most eminent success, both in the explanation of facts already known, and in the discovery of new chemical relations, he does not exclude the possibility of the union of compounds with each other to form compounds of a second order.

Such comparisons of boiling-points have been made, and from them have been deduced, especially by Kopp, a series of very interesting, and certainly not fortuitous coincidences. That distinguished chemist and physicist has shown that, in a very large number of instances, the same change of chemical structure produces nearly the same change of boiling-point. These "laws" of Kopp are only approximate, and are not even approximate in the cases were the boiling-points of the substance compared are very differently changed by change of pressure.

Turning to the other physical character which has been mentioned, namely colour, we see at once a marked regularity. As a rule, substances belonging to the same series differ from one another in degree rather than in kind of colour; while in passing from one series to another, we observe that the colour undergoes a total change of character. This is well illustrated by comparing the colours of substances belonging to such series as the ferrous salts, the ferric salts, the ferrates; the manganous salts, the manganic salts, the manganates and the permanganates; the cuprous and cupric salts, the chromous and chromic salts, the chromates and perchromic acid. Possibly such changes of colour as we see in the transformation of rosaniline and its derivatives into leukaniline and analogous bodies, and of blue into white indigo, may be cases of the same kind. It is also interesting to note, that while the nitro-substitution products of the aromatic series are generally yellow, all the known substances of the same kind in the fatty series are colourless.

These considerations of colour would naturally incline us to regard the operations which lead from one series to another as different in kind from those which lead from one member to another of the series; and when we examine the physiological action of bodies of the same, and of different series, this impression is greatly strengthened.

The speaker described in some detail a few of the observations made within the last two years by Dr. T. R. Fraser and himself, pointing out the similarity of the action of substances belonging to the same series, and the remarkable change of physiological action produced by those chemical changes which lead from one series to another, The illustrations were drawn from the natural alkaloids—a group of substances containing trebly-related nitrogen, and those derivatives of the alkaloids which contain fivefold-related nitrogen. It was shown that the salts of the alkaloids, although containing fivefold-related nitrogen, were not adapted for this comparison, on account of the readiness with which they lose acid in the presence of alkaline substances, their nitrogen thus returning to the trebly-related condition. The bodies formed by the addition of a compound of methyl have not this disadvantage; and as the nitrogen in them is permanently fivefold-related, their physiological action may be satisfactorily compared with that of the alkaloids themselves.

The experiments leading to a knowledge of the action of strychnia and of the salts of methyl-strychnium were described; and it was shown that while the former acts by exciting the origins of the motor nerves in the spinal cord, the latter act by diminishing the action and ultimately paralyzing the terminations of the same nerves in the muscles. Similar relations exist between brucia and methyl-brucium, thebaia and the salts of methyl-thebaium, morphia and the salts of methyl-morphium, &c. Indeed, it may be stated generally that, as far as observation goes, compounds of trebly-related nitrogen exert an action totally different in kind from similar compounds of fivefold-related nitrogen, that a similar difference exists between the triatomic and pentatomic compounds of other members of the nitrogen family, and that this principle appears to be of still wider, and probably general, application.

The speaker, in conclusion, drew attention to the peculiar interest attaching to those regions of science which lie on the frontiers between two distinct departments, as on their successful exploration would depend the ultimate fusion of all physical sciences into one, the science of dynamics, the science which treats of matter and energy, and their relations to one one another. Such a fusion is probably very remote; but we now see in the border-land between chemistry and physics that slow process of absorption going on which has already converted the once independent sciences of sound, light, heat, electricity, and magnetism into more or less completely subjugated provinces of the great empire of applied mathematics. If we believe in the unity of the plan of creation we must believe that this process will advance and ultimately triumph.

## REVIEWS AND NOTICES OF NEW BOOKS.

*Edward Somerset, the 6th Earl and 2nd Marquis of Worcester.* A Medallion; life-size. By James Loft, Sculptor. Exhibited at the Royal Academy, 1867; and now in the Sculpture Gallery of the Crystal Palace, Sydendam. Published by Signor Domenico Brucciani, at his Galleria del Belle Arti, Russell-street, Covent-garden.

This is, so to speak, a *replica* of the bust exhibited at the Royal Academy in 1867, and, rather curiously, the anniversary, two hundred years before, of the death of the author of the "Century of Inventions." To Mr. Dircks is due the great credit of having rescued the name of the Marquis of Worcester from oblivion. His life of the Marquis is a work of great research, and the information collected leads undoubtedly to the fact that the Marquis of Worcester was the first constructor of the steam-engine.

The medallion is executed with great care, and is well worth possessing by those who respect the genius of a man, who, in spite of contumely, made the first steps towards the realisation of one of the greatest inventions of modern times. Those of our readers who have not seen the bust at the Crystal Palace, will do well to visit Sig. Brucciani's studio, not only for the purpose of inspecting the medallion in question, but also to view other works of art there exhibited, and which those of a cultivated taste cannot fail to appreciate.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

The Chicago journals assert that iron can be manufactured in that city at very low rates. Lake Superior pig iron, it is asserted, can be procured at Chicago for 18dols. a ton, and Indiana coal for 2dols a ton. From these facts, it is argued, that smelting furnaces should be established in Illinois and Indiana. The coal is reported to be free of sulphur and of good quality.

Lost Opportunity.—When the Viceroy of Egypt inspected the fire brigade in the gardens of Buckingham Palace, we learn that, in order to illustrate the utility of fire-escapes, certain fire-men went through the form of rescue from the roof of the palace. They assumed, we are told, a helpless state, and were carried down on the backs of their comrades, some being lowered by means of ropes. We almost wish, says the *Pall Mall Gazette*, that at the same time his Highness could have been favoured with other scenes illustrative of our habits which could not have failed to interest him, and would have been useful as warnings, if not as examples. For instance, a few hack cabs might have been driven to the palace gardens, a select number of police constables assuming a helpless condition, while the vehicles were allowed to loiter leisurely through the grounds. The entrance to the palace might have been upheaved by one of our gas companies, then carefully relaid and repaved; upheaved again by the waterworks company, again carefully relaid, and then dug up once more by an underground railway company,—everybody present assuming "the helpless condition." The Viceroy would then have left the palace with a fair idea of the "working of our systems."

On the utilisation of a sewage as a manure, the Hon. Henry Petre writes that his farm (Lodge Farm, Barking) has for the last two years been cultivated with London sewage alone as a manure. There are now upwards of 100 acres bearing corn, root, and other crops, produced solely by sewage, and Mr. Petre has no hesitation in saying that sewage can be profitably and economically used in the cultivation of all the ordinary farm crops of this country.

The Subscription to Mr. George Hudson.—On the 12th ult, a meeting of the subscribers to the fund now being raised for Mr. G. Hudson was held at Harker's Hotel, York—the Lord Mayor being called to the chair. Mr. J. L. Foster, the secretary, reported the sympathy and kindness which had been manifested towards Mr. Hudson in his adversity by men of all classes, and stated that the Yorkshire subscription amounted to £1,280, 5s., exclusive of £70 which had been collected at Leeds by Mr. Pepper, and remitted to Newcastle. The London York, Newcastle, and Sunderland subscriptions amounted to £4,400, and it had been ascertained that for an investment of £4,000 they could obtain £512, which was at the rate of £12, 16s. per cent., as an annuity. The North British had been suggested as the office to the selected. It was resolved that the subscription entered into for the personal benefit of Mr. Hudson, in acknowledgment of his services in connection with public works, be invested in the purchase of an annuity for his life, and a committee was appointed to negotiate for such investment. A vote of thanks to the Lord Mayor and the secretary closed the proceedings.

### TRIAL TRIPS.

Trial Trip of the Clipper Steamer "China."—On July 13th, the magnificent opium clipper steamer *China*, belonging to Messrs. Apear of Calcutta, made her trial trip, under the superintendence of Capt. R. B. Durham, after whose designs she has been built by Messrs. Wigham, Richardson and Co. of Newcastle. The weather was most favourable, and the results in every way satisfactory—the true mean of the runs over the measured mile gave 12·856 knots, the revolutions of the screw being 62, per min. steam 35 to 40lbs., vacuum 27¾in. She then ran from the Coquet to Tynemouth Lighthouse, the tide being slightly in her favour, at the rate of 14 knots an hour over the entire distance. The *China* is a sister vessel to the *Hindostan*, which left the Tyne about two months ago for the East. She is 300ft. long by 35ft. beam, and 24ft. deep, and her engines, made by the well-known firm of Thompson, Boyd, and Co., are of 350-horse power.

### LAUNCHES.

Ship Launch at Stockton.—On Monday evening July 12th, Messrs. Pease and Lockwood, launched from their yard at Stockton, a fine screw steamer of the following dimensions: length between perpendiculars 225ft. breath 33ft. depth 24·9, tonnage 1,283, B.M. She was named the *Capni* by Mrs Nelson, of Shields, and is built for Messrs. Donkin and Co., of Shields, for the Mediterranean trade.

On the 10th ult. a splendid screw steamer, the *Libra*, was launched from the shipbuilding yard of Messrs. Gourlay Bros. and Co., Dundee. The vessel has been built for the General Steam Navigation Company, London. Her keel and fore-rake measure 250ft. her breadth moulded is 30ft.; depth moulded, 17ft. 10in.; tonnage under deck 830; gross register, 985 tons; and she is classed AA at Lloyd's. She will be schooner rigged. Her engines will be surface-condensing and of 250-horse power. Her Passenger accommodation is of the first order, berths being provided for upwards of one hundred each, first and second-class passengers.

### SHIPBUILDING.

The *Albicore*, a small coasting screw, of 385 tons register, built at Port Glasgow by Messrs. H. Murry and Co., and engined by Messrs. Blackwood and Gordon, has just made a favourable trial trip. The *Albicore* has been built for Messrs. J. E. Swan and Brothers, of Glasgow. The *Craigforth*, screw, built and engined by the London and Glasgow Engineering and Iron Shipbuilding Company for Mr. C. Williamson and others, Leith, has also made a trial trip, in which she attained an average speed of 10¾ knots per hour, with a moderate consumption of coal. The *Craigford* is a spar-decked vessel of 1,110 tons gross; her engines, which are on the builders' compound principle, are of 125-horse power, nominal. Mr. J. Elder, of Fairfield, Govan, has launched an iron screw of 400 tons burden. She is named the *African*, and is intended to trade on the West Coast of Africa. She has been built to the order of Messrs. Taylor, Laughland, and Co., of Glasgow. Messrs. Napier and Sons launched the *Europe*, an iron screw, built for MM. Marc Fraissinet et Fils, of Marseilles, and of the following dimensions:—Length, 315ft.; breadth, 37ft. 6in.; depth, 29ft. 6in.; and burden, 2,130 tons. The engines of the *Europe* are of the compound kind, and of 170-horse power. Messrs. Napier have on hand another steamer of similar dimensions for MM. Fraissinet. Messrs. W. Denny and Brothers, of Dumbarton, have launched the *Lismore*, a screw of 616 tons, built for Messrs. Jardine, Matheson, and Co., of Hongkong. The dimensions of the *Lismore* are—Length of keel and fore rake, 180ft.; breadth, 27ft.; and depth, moulded, 19ft. 3in.

Messrs. J. and J. Thomson have contracted to supply the engines of four steamers which are being built by Messrs. W. Hamilton and Co., of Port Glasgow, for the Ottoman Government Messrs. Scott and Co., of Greenock, have an iron paddle, named the *Felis Argentine*, intended for passenger traffic on the River Plate. The *Felis Argentine* will be engined by the Greenock Foundry Company. The *Oberon*, an auxiliary screw, has just left the Clyde for London, where she is loading a cargo for Shanghai. The *Oberon* was built by Messrs. A. and J. Inglis for Messrs. Shaw, Maxton, and Co., of London, and she is expected to make the run out to Shanghai in 75 days. The *Oberon* is 241ft. in length by 36ft. beam, by 21ft. depth. Her burden is 1,235 tons. She is fitted with expansive engines, and can dispense with her propeller when not required, the screw space being enclosed with watertight shutters, by which means the ship presents one unbroken water line, the propelling space causing no resistance whatever when the vessel is under sail.

## RAILWAYS.

The new United States railroad line is now open *viâ* the Harlem Railroad to Lebanon Springs and Manchester, Vt., and Montreal.

The Metropolitan District Railway.—At a meeting of the Metropolitan Board of Works, the engineer (Mr. Bazalgette) reported that about eighty men were employed on the Metropolitan District Railway works on the Thames Embankment, and said that unless the works were carried on more vigorously it would be some years before they were completed.

A Return has been issued of the number and nature of the accidents and injuries to life and limb which have been reported to the Board of Trade as having occurred on all the railways open for traffic in England and Wales, Scotland and Ireland respectively, during the year ended the 31st day of December, 1868. The number of accidents to passenger trains was 92. The result from these was 92 passengers and 10 railway servants killed, and personal injury to 516 passengers and 44 railway servants. Nine accidents occurred to goods and mineral trains, whereby eight railway officials were killed and five were injured.

The street railway companies of Cincinnati have adopted the following expedient with the two-fold object of encouraging travel on their lines and of diminishing the opportunities for stealing on the part of conductors. All the tickets are numbered, and are like theatre tickets in having coupons. The passenger retains one part with a number upon it corresponding to that which he gives up. All the tickets taken in a week are saved, placed in a wheel, and one is drawn out. The holder of the coupon whose number corresponds to that of the ticket, draws a prize of fifty dollars.

The returns of the several railroad corporations in the State of Massachusetts, show that 24,916,021 passengers were transported by them for greater or less distances during the year ending November 30, 1868 and out of this vast number not one was killed or injured while occupying his seat, although several were fatally hurt while attempting to get on or off the trains while in motion.

Wooden Rails.—A company has been organized, so we are informed, at Stevens Point, Wisconsin, to construct several miles of wooden track railway. It is proposed to use hard maple, and to treat it with some preparation to harden the wood and to preserve it from rotting.

A contract has been concluded between the Baltimore and Ohio and the Indiapolis Cincinnati, and Lafayette Railroad Companies for permanent business connections to and from the West *viâ* Cincinnati. This arrangement provides for through trains, rates, and proper facilities for the development of a joint traffic. The former company becomes largely interested in the securities of the latter. The arrangement is regarded as very important particularly to the cities of Cincinnati and Baltimore.

An action was brought some time ago against the Hammersmith and City Railway Company to recover damages for alleged injury to a house caused by the vibration of the trains on the company's lines. The Court of Queen's Bench decided that no compensation could be claimed, because the running of the trains was the authorised and legalised use of the railway. The Exchequer Chamber reversed this decision, and the case was taken to the House of Lords, who reversed the decision of the Exchequer Chamber and affirmed that of the Court of Queen's Bench. Lord Cairns differed.

## TELEGRAPHIC ENGINEERING.

The submarine cable between Peterhead, in Scotland, and Iggersund, in Norway, has been successfully laid by Mr. W. T. Henley, of North Woolwich, and forms one of the links of the Great Northern Telegraph Company.

The Black Sea Cable.—It is announced that the cable of the Indo-European Telegraph Company across the Black Sea, about 200 miles in length, has been successfully submerged.

## APPLIED CHEMISTRY.

According to Bottger, the metal antimony may replace graphite in galvanic batteries. He finds the following arrangement preferable, as regards force and durability, to either Daniells', Minotto's, or Leblanche's batteries:—A cylinder of amalgamated zinc is placed in a concentrated solution of equal parts of common salt and sulphate of magnesia; the antimony is placed in a porous cell filled with dilute sulphuric acid.

Production of Ozone for Industrial Purposes.—M. Beanes, as noted in the *Genie Industriel*, recently exhibited to his scientific-friends an electrical apparatus for the production of ozone at a small cost, which has not received the attention it deserves. His apparatus consists in a condenser between the plates of which atmospheric air, the oxygen of which is to be ozonized, is made to pass. The electricity acts here by influence and directly. The gas, on leaving the machine acts energetically on india-rubber, turmeric, etc. It is suggested that this simple electrical ozonizer might probably be applied with profit to the bleaching of tissues, liquors, and other substances.

M. Delamier, in a communication to the Academy of Sciences, states that the following mixture forms an exciting liquid for galvanic batteries of great energy and economy, disengaging no deleterious fume or gas:—Dissolve twenty parts, by weight, of protosulphate of iron in thirty-six parts of water. Then stir in seven parts of a solution of sulphuric acid (equal parts); then in the same manner add one part of diluted nitric acid (equal parts).

Adulteration of Glycerine.—Owing to the increased demand for glycerine for various purposes, its adulteration has of late become very common, especially with dextrine and with ordinary sugar, the detection of which when used in small quantities, has hitherto been extremely difficult. This, however, is now rendered easy by the blue tint which the sophisticated article will assume if boiled with diluted nitric acid and molybdate of ammonia.

Detection of Arsenical Pigments.—M. C. Puscher states—That during the first five months of this year, no less than eight cases of accidental poisoning by these pigments have occurred at Nurenberg; he advises the use of liquid ammonia for the detection of these pigments, all of which, he says, are soluble therein, exhibiting a blue coloured solution, if copper is at the same time present; he further states that, on the evaporation of the ammonia, there remains a dirty greenish coloured precipitate of arsenite of oxide of copper; his advice is to paint some *white* paper with this solution in ammonia, which painting, when dry, if arsenic were present, will exhibit a dirty greenish colour, but if after drying a blue colour appears to have been imparted to the paper the pigment is quite free from arsenic, and only consists of a compound of copper, of which latter metal there are several in use, as green and blue pigments, all soluble in ammonia, except such adulterations as do not essentially belong to the pigment itself.

## ACCIDENTS.

Locomotive Explosions.—No fewer than fourteen locomotives have exploded within the past seven months in the United States, killing twenty-nine persons out-right and severely wounding a much greater number.

Steamboat Casualties on the Western Waters.—The Cincinnati *Commercial* has published a list of steamboats sunk, blown up, or burned on the Western rivers since Sept, 30, 1867, and gives the sum total as follows:—Destroyed by fire forty-nine; by sinking, one hundred and one; by explosion, fourteen. All these one hundred and sixty-four steam vessels were total losses, and their aggregate tonnage was something over thirty-four thousand seven hundred tons.

## LATEST PRICES IN THE LONDON METAL MARKET.

|  | From |  |  | To |  |  |
|---|---|---|---|---|---|---|
| COPPER. | £ | s. | d. | £ | s. | d. |
| Best selected, per ton | 76 | 0 | 0 | ,, | ,, | ,, |
| Tough cake and tile do. | 74 | 0 | 0 | 75 | 0 | 0 |
| Sheathing and sheets do. | 79 | 0 | 0 | 80 | 0 | 0 |
| Bolts do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 81 | 0 | 0 | 83 | 0 | 0 |
| Old (exchange) do. | 65 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. |  |  |  |  |  |  |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7 | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6½ | 0 | 0 | 6¾ |
| SPELTER. |  |  |  |  |  |  |
| Foreign on the spot, per ton | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. to arrive | 20 | 15 | 0 | ,, | ,, | ,, |
| ZINC. |  |  |  |  |  |  |
| In sheets, per ton | 26 | 0 | 0 | 26 | 10 | 0 |
| TIN. |  |  |  |  |  |  |
| English blocks, per ton | 123 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 124 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 131 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 135 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 132 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* |  |  |  |  |  |  |
| IC. charcoal, 1st quality, per box | 1 | 7 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 13 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 2nd quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. Coke do. | 1 | 2 | 0 | 1 | 4 | 0 |
| IX. do. do | 1 | 8 | 0 | 1 | 10 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. |  |  |  |  |  |  |
| Bars, Welsh, in London, per ton | 6 | 15 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 15 | 0 | ,, | ,, | ,, |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 0 | 0 |
| Bars do. do. | 7 | 7 | 6 | 8 | 0 | 0 |
| Hoops do. do. | 8 | 0 | 0 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | 6 | 5 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 7 | 5 | 0 | 7 | 10 | 0 |
| Do. Swedish in London do. | 9 | 17 | 6 | 10 | 0 | 0 |
| To arrive do. | 10 | 0 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 11 | 6 | 2 | 18 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| STEEL. |  |  |  |  |  |  |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 5 | 0 |
| Do. in faggots do. | 15 | 15 | 0 | 16 | 0 | 0 |
| English spring do. | 19 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. |  |  |  |  |  |  |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 10 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 15 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | ,, | ,, | ,, |
| Spanish do. | 18 | 10 | 0 | ,, | ,, | ,, |

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*At the works 1s to 1s.6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated June 18th, 1869.

1871 T. Bourne—Velocipedes
1872 J. G. Tongue—Production of novel effects in the manufacture of various articles of glass
1873 I. Gregory and E. Ainsworth—Improved drag motion
1874 H., and F. C. Cockey—Economising consumption of fuel
1875 J. Napier—Cooking ranges
1876 G. Molland—Axle boxes
1877 W. Topham and S. Wells—Handles of kettles
1878 M. Andrew—Locks
1879 W. R. Lake—Permanent way
1880 E. Haas and V. Wanostrocht—Improvements in pushing jacks

### Dated June 19th, 1869.

1881 T. Silver—Holding letters
1882 J. Bullough and C. Catlow—Improvements in looms
1883 S. Holmes—Microscopes
1884 H. A. Bonneville—Compounding and applying compounds, &c.
1885 A. S. Harington—Pouch for tobacco
1886 H. Bauerrichter—Show cases
1887 C. E. Brooman—Ascertaining weights and strains
1888 J. B. Brooks and G. Picken—Sticks of umbrellas, &c.
1889 F. Forder and J. Traves—Velocipedes
1890 E. H. C. Monckton—Iron and steel
1891 S. Nicholls—Tilling land
1892 R. Olpherts—Indigo presses

### Dated June 21st, 1869

1893 M. Olsson—Preserving animal substances
1894 W. Pidding—Locomotion
1895 A. J. Glas—Decorticating grain
1896 B. Bell—Affixing sheathing to ships
1897 A. Manbre—Preparing and treating cereal and other vegetable substances, &c.
1898 P. G. B. Westmacott—Cranes
1899 W. R. Lake—Blowing engines
1900 W. R. Lake—Wheels
1901 T. F. Cashin and J. Green—Improvements in furnaces

### Dated June 22nd, 1869.

1902 C. D. Abel—Opening gates, &c.
1903 J. Martin—Process for rendering cloth repellant of water
1904 G. Musgrove—Indicating signals
1905 W. Clark and E. Walker—Construction of windlasses
1906 T. and R. Nuttall—Weaving counterpanes
1907 J. C. Norman—Plough
1909 J. I. Evans—Tin plates
1910 R. R. Kelly—Supplying furnaces with coal, &c.
1911 W. R. Lake—Combustible compound
1912 M. Henry—Composing, &c.
1913 H. T. Munns—Camera obscuras

### Dated June 23rd, 1869.

1914 R. Moreland and D. Thomson—Improvements in steam rollers
1915 W. Spence—Sugar, &c.
1916 J. H. Johnson—Injectors for feeding steam generators
1917 D. P. Park—Removing animal substances from bottoms of vessels
1918 A. J. Dehlon—Calendering stuffs
1919 O. Zabel—Grease box
1920 A. M. Clark—Telegraph apparatus
1921 A. M. Clark—Safety lamp
1922 H. A. F. Duckham—Gas regulators

### Dated June 24th, 1869.

1923 R. Caunce, M. G. Bradley, and B. Bradley—Twisting yarns
1924 W. W. Neame—Fencing
1925 R. N. Williams—Reflectors
1926 S. Joy—Apparatus for removing the dust from rag machines
1927 J. Macintosh—Waterproof varnishes
1928 J. Brooke and J. Hirst—Improvements in paddings
1929 J. Taylor, R. Ingham, J. Ingham, and J. Charplea—Carding engines
1930 R. Olpherts—Shears
1931 A. H. Still and D. Lane—Gas
1932 W. Bracelin—Velocipedes

### Dated June 25th, 1869.

1933 W. Palliser—Key fastenings
1934 W. F. Williams—Improvements in boxes for holding jewellery, &c.
1935 J. Heys, J. Duckworth, and G. Barnes—Carding engines
1936 H. Caro, C. Graebe, and C. Lieberman—Preparing colouring matters
1937 J. Lamb—Bobbin frames
1938 A. B. Childs—Catamenial sacks
1939 C. Cochrane—Smelting

### Dated June 26th, 1869.

1940 W. Madders—Embroidering machines
1941 F. Lecoultre—Changing the barrels of musical boxes
1942 J. Donald—Finishing woven fabrics
1943 John Lomax—Depositing the stive or flour contained in the air discharged from millstones
1944 J. Lomax—Preventing the deleterious effects of back lash in driving millstones
1945 F. Wohlgemuth—Changing a breech loading gun into a rifle
1946 A. Clark—Permanent way and rolling stock of railways
1947 T. Gray—Varnishes
1948 W. H. Perkin—Colouring matter
1949 G. Fielding—Smoke burner
1950 A. Bowring—Shirt collars

### Dated June 28th, 1869.

1951 W. P. Wilding—Spinning cotton
1952 C. D. Abel—Ventilating hat
1953 M. Kennedy—Scales
1954 J. W. Burton and R. W. Morrell—Combined woven and felted fabrics
1955 G. T. Smith and C. Challenger—Manufacture of floor cloth
1956 J. Howard—Horse rakes
1957 W. R. Lake—Refining lard, &c.

### Dated June 29th 1869.

1958 G. C. Haswell—Water directors
1959 C. L. V. Yon—A new kind of portable camping trunk
1960 W. Cowan—Locomotive engines
1961 W. Blackburn—Standards for benches, desks, and tables
1962 E. T. Hughes—Manufacture of sugar, &c.
1963 W. Bartram—Cartridges

### Dated June 30th, 1869.

1964 H. Yates—Improvements in means applicable to twist lace machinery, &c.
1965 H. H. Courtenay—Printing surfaces
1966 B. Templar—Combined apparatus for damping and cleaning slates
1967 M. Turnor—Manufacture of metallic and other boxes
1968 R. Brown—Iron
1969 W. E. Gedge—Carriage spring
1970 W. E. Gedge—Incorporation of extract of meat with sweetmeats
1971 D. Hebson—Steam engines
1972 R. Knowles and J. Lindley—Ladies' night dress cases
1973 R. Heyworth—Waterclosets
1974 W. H. Bailey—Improvements in cutting machinery
1975 R. Boyd—Signals
1976 J. Robinson—Means of preserving animal substances

### Dated July 1st, 1869.

1977 A. Walker—Agricultural implements
1978 W. E. Gedge—Safety break
1979 R. W. Whitehead—Coupling or jointing pipes or tubes
1980 W. Coleman and S. Turton—Improvements in feeding bottles
1981 R. Porter—Furnaces
1982 T. Atwater—Improved band
1983 J. Stringfellow—Affording protection from bullets, &c.
1984 J. D. Dougall and W. Bartram—Apparatus for filling cartridges
1985 J. H. Johnson—Firearms
1986 A. Barclay—Engines
1987 L. F. Banks—Improvements in markers for croquet
1988 A. V. Newton—Manufacture of nail or spike, &c.
1989 A. Turner—Improvements for utilising waste strips of india rubber
1990 H. Larkin and W. White—Production of sodium, &c.
1991 E. Roe—Looped fabrics

### Dated July 2nd, 1869.

1992 T. Jones—Attaching together the barrels of firearms
1993 H. A. Bonneville—Improved billiard room convenience
1994 H. A. Bonneville—Motive power
1995 E. Scott—Preparing fibrous materials, &c.
1996 S. Smithson, G. Senior, and J. Inman—Valve taps, &c.
1997 S. Brooke—Carding wool
1998 G. White—Steam engine
1999 C. D. Abel—Preparing corks
2000 H. Turner—Weaving
2001 W. Frazer—Materials for fettling or lining furnaces
2002 W. R. Lake—Bag and chair
2003 J. Smithers—Galvanic batteries
2004 W. A. Biddell—Ornamental articles in glass, &c.
2005 A. V. Newton—Preparing flax, &c.
2006 H. E. Newton—Measuring liquids
2007 J. Steward—Pianofortes
2008 A. Foucaut—Telegraph cables

### Dated July 3rd, 1869.

2009 P. G. Gardiner—Improvements in springs for railroad cars, &c.
2010 N. Mole—Boots
2011 A. Angell—Hulling coffee, &c.
2012 A. H. A. Duraut—Preparing castor seeds for oil, &c.
2013 T. Grahame—Barges, &c.
2014 I. James—Crushing bones
2015 G. Palmer—Biscuits
2016 J. Hart—Utilizing sewage
2017 T. Butler and R. F. Carey—Lace
2018 C. Churchill—Drawing nails
2019 J. Clark—Steam boilers

### Dated July 5th, 1869.

2020 T. Smith—Utilising the waste heat of puddling and ball furnaces
2021 W. Duckworth the younger—Taps
2022 F. W. Gruue—Transferring photographs
2023 T. Wilson—Velocipedes
2024 W. R. Lake—Water meters
2025 L. Falisse—An improved breech-loading firearms
2026 W. E. Newton—Bar iron
2027 J. Knight—Improvements in four wheeled vehicles

### Dated July 6th, 1869.

2028 G. Buchanan—Improvements in preserving animal and vegetable substances for use as food
2029 W. B. Haigh—Cutting, sawing, and boring wood
2030 J. Gedge—An arm and reclining chair for travellers
2031 C. D. Abel—Composing and distributing type
2032 W. Walker—Motive power engines, rotary pumps, and fans
2033 W. L. Wise—Lubricating the cylinders of steam engines
2034 C. Crockford—Treating the ores of lead or products containing lead
2035 C. E. Brooman—Heating and distilling water
2036 L. Clayton, L. Clayton, and J. Smith—Taps or valves
2037 W. Bray—Refrigerators
2038 W. Q. East—Apparatus for indicating the flow of liquids
2039 W. Pidding—Obtaining scents

### Dated July 7th, 1869.

2040 J. Shore—Cards used in carding engines
2041 D. Cope—Prevent waste of liquids in filling casks
2042 H. E. Knight—Busks
2043 F. Walton—Scrapers
2044 J. B. Rogers—Velocipedes
2045 V. A. Deaubeuf—Compressing and moulding coal
2046 A. P. Price—Anæsthesia
2047 R. Mallett—Manufacture of iron and steel
2048 F. Trappes—Velocipedes
2049 J. Robinson—Machinery for cutting dovetails
2050 W. E. Newton—Decarbonising iron
2051 W. Arnold and W. Caruelley—Steam boilers
2052 A. V. Newton—Chandeliers
2053 W. R. Lake—Removing artificial coatings from metallic surfaces
2054 J. H. Johnson—Preparation of meat for preservation, and preservation of the same
2055 R. P. Faucheux—Boxes or holders for matches and other articles

### Dated July 8th, 1869.

2056 C. S. Berthon—Squares for finding centre of circles
2057 J. G. Rollins—Reaping and mowing machines
2058 J. Wright—Shaving mug
2059 W. Davis—Tallow used in candles and soap
2060 T. Knowles—Wrought iron permanent way for railways
2061 I. Williams and R. C. H. Wallendahl—Fish hooks
2062 I. L. Pulvermacher—Chains for producing electric currents

### Dated July 9th, 1869.

2063 W. Hutchinson—Bricks, &c.
2064 H. H. Murdoch—Propelling canal boats and other vessels
2065 T. James—Sewing machines
2066 F. Baker—Securing gates
2067 J. H. Jones—Lamps
2068 M. A. Muir and J. McIlwham—Improvements in looms
2069 J. Aitken—Motive power
2070 G. A. Nowell—Lamps
2071 F. J. Manceaux—Firearms, &c.
2072 W. Allan and P. D. Nichol—Improvements in steam generators

### Dated July 10th, 1869.

2073 A. M. Clark—Measuring time, &c.
2074 J. W. Jackson—Breakwaters, &c.
2075 I. Walker and P. A. Godefroy—Manufacture of dyes
2076 C. E. Brooman—Cartridges
2077 J. Gessert—Recovery of nitric acid in the manufacture of sulphuric acid
2078 T. Kendrick—Knobs, &c.
2079 T. D. Waller—Cask stand
2080 C. L. Calkesi—Kitchen cart
2081 J. Beard—Pumps
2082 S. Read—Finishing textile fabrics, &c.
2083 J. S. Crosland—Improvements in marine steam engines
2084 J. B. Couper—Horseshoes
2085 J. Bannehr and H. Matthews—Drying, &c., woven fabrics
2086 J. Worth and W. Turner—Cards for carding cotton
2087 W. R. Lake—Producing marquetry
2088 W. R. Lake—Horseshoes
2089 W. R. Lake—Sofa bedstead
2090 W. R. Lake—Sawing, &c., wood

### Dated July 12th, 1869.

2091 Q. Dunlop, T. J. Martin, and W. Orr—Couplings, &c.
2092 J. Dewar—Treating certain substances for food and manure
2093 C. A. Bates—Apparatus to be applied to the mouths of letter boxes
2094 F. Sutton—Speaking pipes
2095 L. Schalleidner—Improvements in engine to stamp waxlights
2096 W. Bayliss—Rick stands
2097 J. Henderson—Refrigerators
2098 C. D. Abel—Cleansing grain
2099 C. Mertons—Cartridge box
2100 E. Pettitt—Spinning cotton
2101 J. H. Player—Utilising residual sulphate of lime, &c.
2102 W. R. Lake—White lead
2103 C. F. Dunderdale—Apparatus for generating hydrogen gas

### Dated July 13th, 1869.

2104 C. A. C. de Goddes de Linncourt—Improvements in life belts
2105 C. Chapman—Pumps
2106 J. Piret—Slide valves of steam engines
2107 T. Restell—Breech loading arms
2108 C. P. E. Roche—Improvements in the conversion of cast iron, &c.
2109 W. P. Bain—Sails for ships
2110 F. J. Smith and L. J. Abbott—Effervescing drinks
2111 R. Craig—Paper making
2112 A. V. Newton—Mowing machines
2113 R. Whittaker—Teetotums
2114 S. E. Crispe and J. West—Heating by means of steam
2115 J. Barnett—Firearms

### Dated July 14th, 1869.

2116 I. Baggs—Generation of ammonia
2117 C. Shether—Duplicate lock
2118 J. A. Horlick—Pianoforte hammers
2119 J. A. Horlick—Pianoforte bridges
2120 T. Richards—Stoves
2121 R. Willcox—Instruments for picking up submarine cables
2122 M. Jack—Agricultural implement
2123 J. W. Rein—Manufacture of paper
2124 J. Leetch—Spring stopper
2125 J. Leetch—Communication between the different parts of a railway train

### Dated July 15th, 1869.

2126 V. Coine—Aero-hydraulic engine
2127 J. Crowther—Seats of railway carriages
2128 J. Crowther—Working hoists
2129 J. Crowther—Velocipedes
2130 J. Leeming and J. Leeming—Improvements in looms
2131 G. Lowry—Dressing flax
2132 W. W. H. Smith—Upper leathers for boots
2133 B. J. B. Mills—Annealing metals
2134 A. Adamsz—Cigarettes
2135 C. de Bergue—Locomotives
2136 J. J. Cousius—Indicating the points made at billiards
2137 J. T. A. Mallett—Charging atmospheric air with oxygen
2138 C. D. Abel—Coiled springs
2139 J. T. Wray—Hydrochloric acid
2140 J. Bernard—Smelting
2141 J. H. Johnson—Agricultural implements
2142 J. Bernard—Utilising heat

### Dated July 16th, 1869.

2143 J. E. Millar—Machinery for raising the nap of woollen cloth
2144 W. Hosack—Evaporating liquids
2145 W. Hosack—Improved ship
2146 J. Grint—Saw benches
2147 W. R. Lake—Improvements in propelling machinery
2148 R. P. Williams—Improvements in railway crossings
2149 J. W. Ormiston—Blast furnaces
2150 G. Yates and J. R. Williams—Opening cucumber frames, &c.
2151 F. G. Fleury—Drawing liquids
2152 R. B. Evered and R. Hurst—Apparatus for raising water
2153 A. Rollason—Extracting ammonia, &c.

### Dated July 17th, 1869.

2154 B. Russ—Bicycles
2155 P. Murray—Rocking firebars
2156 W. Pidding—Mosaic fabrics
2157 H. Mege—Fatty bodies
2158 E. F. Jones—Nails, &c.
2159 H. E. Newton—Firearms
2160 H. E. Newton—Electro magnetic engines
2161 A. Simpson—Cleaning knives
2162 M. Eyth—Carrying road wheels
2163 D. N. Defries—Gas meters
2164 A. Ancion—Firearms
2165 C. Hook—Velocipedes
2166 J. H. Johnson—Blasting, &c.
2167 C. J. Harcourt—Axle pulleys, &c.
2168 J. Bernstein—Umbrella handles

### Dated July 19th, 1869.

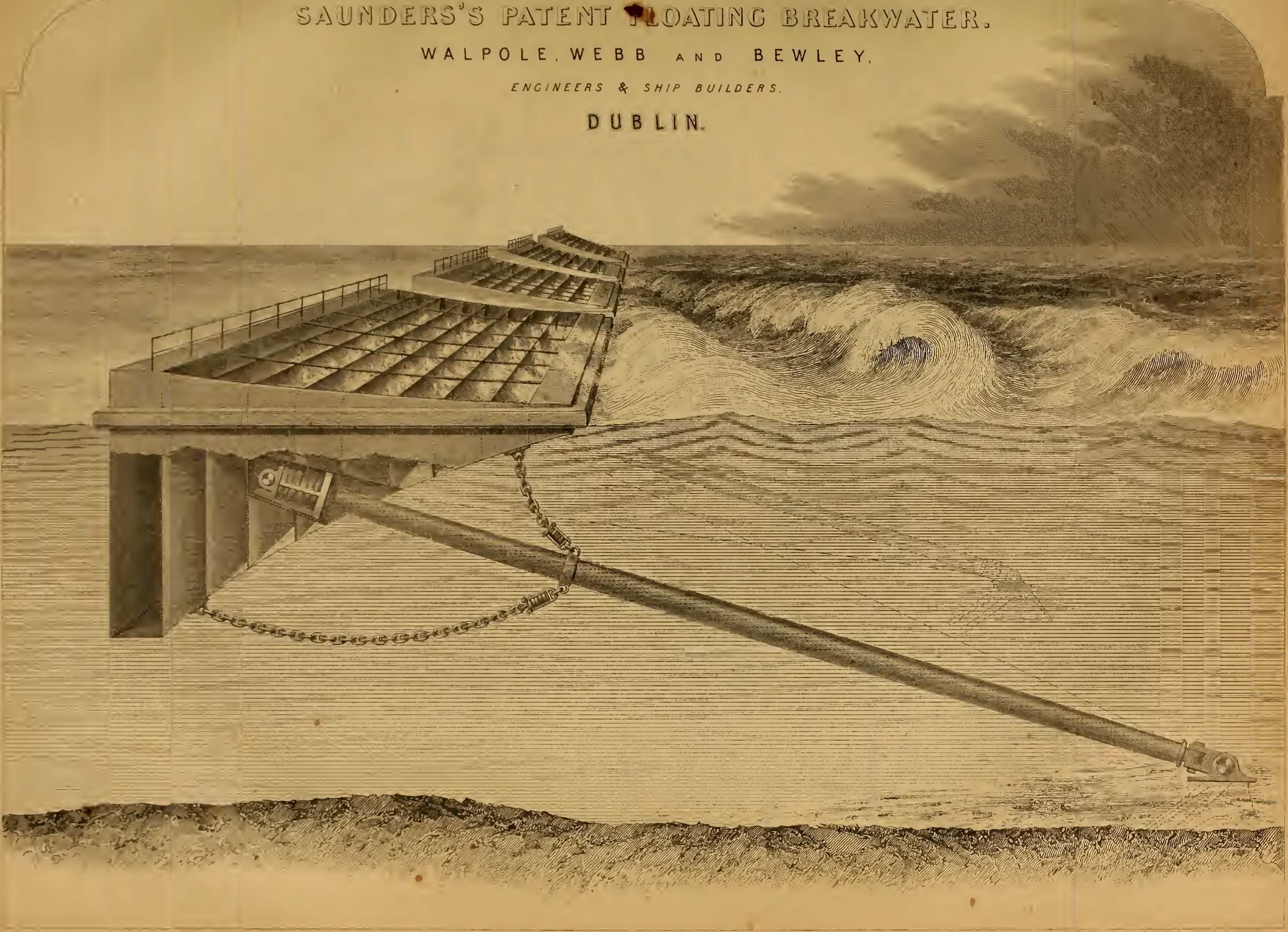
2169 W. Furness—Cutting files, &c.
2170 J. H. Johnson—Sewing machines
2171 J. Imray and G. G. M. Hardingham—Sewing machines
2172 B. Looker—Earthenware box
2173 W. Leftwich—Velocipedes
2174 W. Macgeorge and A. Rigg—Starting steam engines
2175 R. Neale—Transfer engraving
2176 W. E. Gedge—Generating steam
2177 A. M. Clark—Cables
2178 R. Schloesser and J. Irving—Converting wood shavings into paper pulp
2179 V. E. Maugber—Ink absorber
2180 B. Hunt—Looms
2181 R. Duerre—Lever manumotive apparatus
2182 J. B. Fondu—Blowing glass
2183 T. Thomas—Mills for grinding corn, &c.
2184 W. Williams—Elastic horse boot

### Dated July 20th, 1869.

2185 R. G. Fisher—Rafters for roofs
2186 T. Holt—Distributing disinfectants to closets
2187 R. Olivier—Velocipedes
2188 F. Fleming—Driving straps
2189 R. Saunders—Buffing railway carriages, &c.
2190 J. Rehse—System for the cure of stammering
2191 J. E. Holmes—Securing the free ends of wire ropes
2192 W. Rose—Bearings for cast iron rails
2192 D. Trevor—Production of photographic pictures

# SAUNDERS'S PATENT FLOATING BREAKWATER.

WALPOLE, WEBB AND BEWLEY,
*ENGINEERS & SHIP BUILDERS.*
**DUBLIN.**



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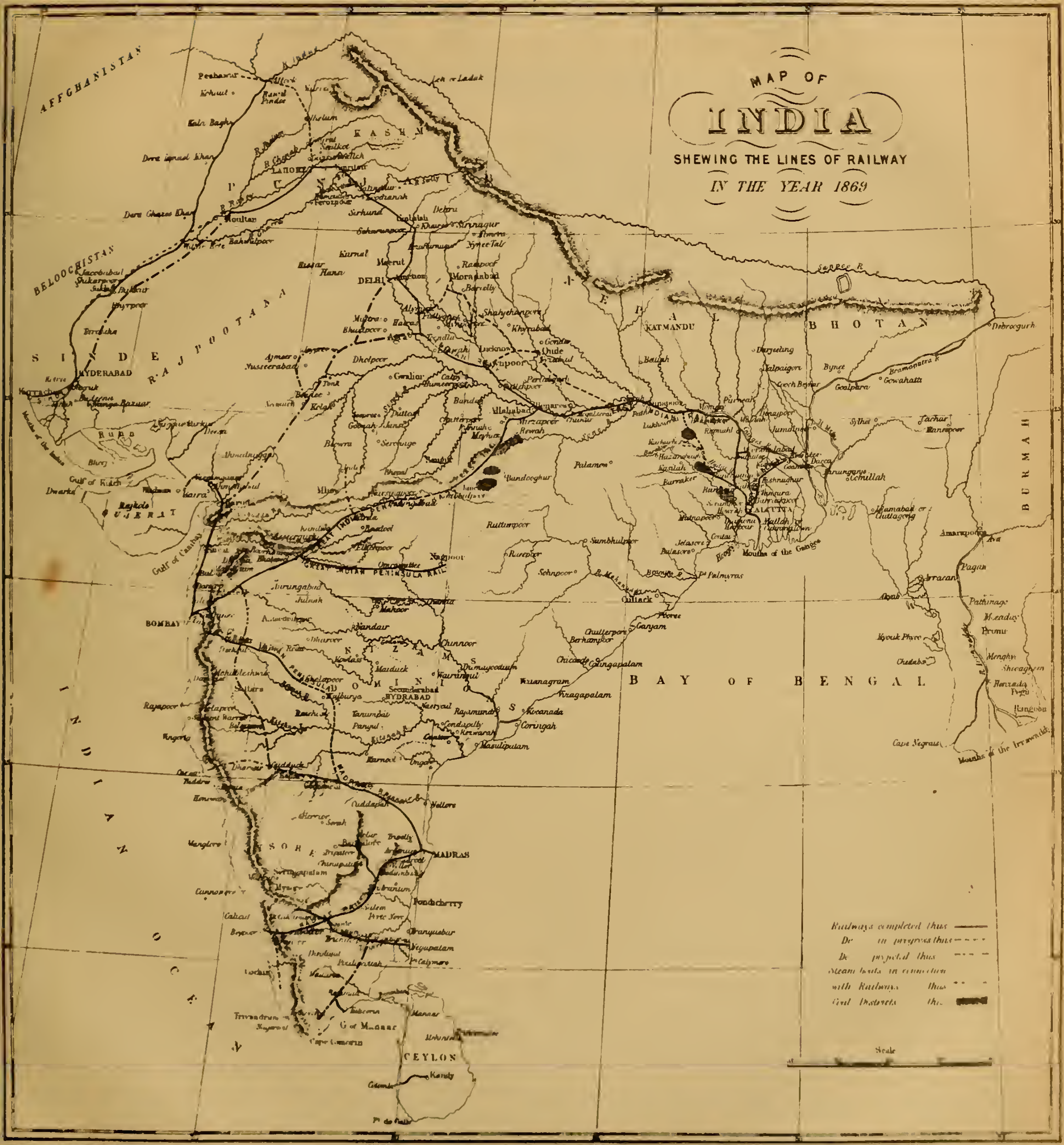

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# THE ARTIZAN.

No. 9.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. SEPTEMBER, 1869.

## RAILWAYS IN INDIA.

(*Illustrated by Plate* 352).

Although several articles upon the subject of railways in connection with roads and canals have lately appeared in The Artizan, we feel sure we need make no apology for adverting to several despatches that have lately passed between the Governor-General of India and the Duke of Argyll, Secretary of State for India, and which have lately been printed.

The first despatch, dated March 11th, 1869, relates to the agency by which the future railways in India should be constructed, and after quoting the minutes of Sir John Lawrence, sums up his conclusions in reference to the subject by stating that he was of opinion that railways should be carried out by the Government itself, so far as consistent with the actual and implied engagements with existing companies. The Government had been forced into the conviction that the present arrangements with the Indian railway companies, precluded it from sufficient control in the expenditure to protect its financial interests, and this appears to be the principal motive for avoiding the agency of companies for the future. The average cost of Indian railways, which is about £17,000 per mile, is considered to be far too high in proportion to the amount of traffic, scarcely any of the lines paying more than 5 per cent., while the average is only 3 per cent. As the present lines naturally run through the richest provinces and largest towns, it can hardly be expected that the returns from the new lines, which have been recommended, will equal those obtained on the lines in operation, and consequently it is an essential condition that the cost of construction shall be largely diminished. In order to effect this purpose it is proposed that in any future arrangement with a company for carrying out railways the Government of India should have the power of limiting the capital outlay to what is deemed strictly necessary; and in the event of its being of opinion that the railway is not being constructed satisfactorily, or is not likely to be completed for the sanctioned estimates, or with proper expedition, it should have the power of taking the works from the company. The Government felt very strongly the objection there might be in some cases to allowing companies to carry out works in native states, and proposed to lay down as a principle, that the inexpediency of admitting them should be presumed until the contrary had been most satisfactorily proved. And lastly, the Government deprecated any attempt to throw upon it the invidious duty of constructing only lines of railway which cannot pay. As regards this clause the feeling may be very natural, but we cannot understand how the Government can expect companies with their eyes open, to undertake political non-paying lines unless they are far more charitable in India than in other parts of the world.

The next despatch, dated the 11th of March, 1869, adopted the approximate supplied in Sir John Lawrence's minute of the 9th of January, 1869, and entirely accepted the general conclusions based on that estimate:—

"1. That every part of India which can at the present time be reasonably regarded as requiring railways could be brought within a general network of lines, the aggregate length of which would be about 15,000 miles, of which about 4,000 are opened, 1,000 miles are in progress, and 900 miles are about to be put in hand.

"2. That by the continued expenditure of about 3½ millions yearly it might be possible to open, on an average, 300 miles of railway yearly, reckoning the average cost per mile of the new lines to be £12,000.

"3. That such a supply of capital might probably be forthcoming for the purpose in question, in addition to the sums required for Irrigation and other works of improvement for which money must be borrowed, without seriously disturbing the money market.

"4. That the resulting charge, in the shape of the excess of the sum to be paid for interest over the net receipts of the open lines, would not be likely to exceed the amount which could be spared from the revenues for the purpose of carrying out these extremely important works, and that any necessary adjustment between the actual charge and the available resources of the Government could readily be made by reducing or increasing the rate of annual outlay.

"5. That by the regular prosecution of railway extension on some such moderate and persistent system the great requirements of India could, in all probability, be met in a period of thirty years from the present time, without extraordinary taxation, inconvenient pressure on the public revenues, or objectionable increase of the liabilities of the state."

The Government was of opinion that the Indus Valley railway should be undertaken early, but that it should not be pushed on so as to affect the labour market, which is but poorly supplied along the whole line. By beginning at Moultan and working downwards, the navigation of the worst portion of the Indus would be obviated at the earliest period. There was ground for thinking that, by combining the excavation of a main line of canal from Sukkur towards Hydrabad with the formation of the railway an important saving of expense might be secured.

A railway through Rajpootana to connect the North-Western provinces with Bombay is also recommended to be commenced at once.

A short line to the Kumaon Ironworks from the Oude and Rohilcund Railway would be of great importance with reference to the cheap provision of iron for the railways of Northern India.

The Darjeeling Railway, Kooshtee to Titalyah (210 miles) is said to be one which commends itself for early construction on many grounds of policy, but at present there is some doubt regarding the exact line to be followed, which has not yet been finally settled.

The East Coast Railway between Calcutta and Madras is also proposed, although there appears to be some doubt as to the exact direction it should take and also as whether it would not be desirable to make it a narrow gauge railway.

Short branches are proposed in connection with the Madras main line, also a railway to Tuticorin; the southern section, west coast railway from Beypoor to Calicut on the north, and to Cochin on the south. The west coast railway, northern section, is recommended so far as regards the line from Carwar to Dharwar or Hooblee, so as to concentrate the trade at the new port of Carwar. A gradual development of railways in Mysore might be carried out from Bangalore with the intention of their eventually joining into the Southern Mahratta series, and so giving an additional outlet to Mysore by Carwar. The Hydrabad railway, Koolburga to Hydrabad (116 miles), should be taken up at once as a state line, and the junction of north-east and south-east branches of the Great Indian Peninsular railway, Munmar to Doondh (132 miles) must also fall to the Government, as the Great Indian Peninsular Company have declined to accept it. As there is but little chance of this line paying for an indefinite period, if carried out in the usual manner, it is recommended that it should be a light line of about 3ft. 6in. gauge Branches to the Great Indian Peninsular Railway, if constructed cheaply, are admitted to be desirable, but proper precautions should be taken to limit the outlay upon them. The same remarks also apply to the branches to the Bombay and Baroda Railway. The Ahmedabad to Voorungaum and Wudwan (73 miles) might be given to the Bombay and Baroda Company, subject to similar precautions respecting the outlay on its construction. The Kattywar lines should receive early consideration, and might be carried out by the state. The railway from Rangoon to Prome (166 miles), which is also recommended to be carried out by the state, concludes the review of those lines to which it is considered immediate attention required.

The third despatch, dated March 22nd, 1869, discussed generally the question of the administration and construction of Indian railways, stating that everything which tended to increase the railway income, and to reduce the charges for management directly operated on the payments under the guarantee. They were of opinion that a far more rigid scrutiny must be exercised over those constant additions to the guaranteed capital of the numerous companies for minor additions and improvements. When it was considered that the guaranteed railway capital would before many years almost certainly amount to £100,000,000, on which the interest charge would would be £5,000,000, and that the receipts were gradually approaching to double that amount, the vast proportions of the stake which the Government had in those works would be better appreciated. The gross traffic earnings of the Indian railways at the present time already exceeded £6,000,000, a sum greater than the entire revenues of the North-West Provinces, and when the receipts sufficed to cover the guaranteed interest they would exceed the revenues of any province of India excepting Bengal, and amount to one-fifth of the whole revenues of the country. In like manner the railway current expenditure, which was now about £3,000,000, nearly equalled the whole expenditure of the Madras presidency, excluding the army, and exceeded that of the North-western Provinces. They very earnestly submitted that the Government of India should, as far as practicable, be henceforth left to be the final authority, acting through the several local governments, in respect to all the details of transactions arising in India between the guaranteed railways and the Government; and that the Secretary of State should reserve to himself the management in detail of business arising in England. It would always be their wish to conform to the 5½ft. gauge, if the financial objections to it were not insuperable; but they hoped, when the prospects from any contemplated system of lines were not satisfactory, to be authorised to construct them on a narrow gauge of, say 3½ft., instead of the ordinary broad Indian gauge of 5½ft. In conclusion, the despatch stated that the time has come when India should cease to lean exclusively upon English engineers in dealing with its railways, and should commence the regulation of these works in more strict conformity to the special wants and special means of the country itself. But to ensure proper success, the control of these undertakings must be exercised in India both as regards the essentials of construction and management.

The following reply of the Duke of Argyle, Secretary of State for India, to these despatches, is so important that we give it *in extenso* :—

"India Office, London, July 15th, 1869.

"My Lord,—1. I have had under consideration in council your despatches replying to three from Sir Stafford Northcote, on the general subject of railway extension in India, and exhibiting the views of your Excellency in Council as to the railway policy fitting to be pursued in future.

"2. The subject is arranged by you under three heads, each of which you have found it convenient to treat separately; the most suitable agency for the construction of railways being discussed in the first of your despatches, the relative claims of particular lines to early construction in the second, and certain special questions connected either with construction or subsequent administration in the third.

"3. Under the first and third heads some weighty matters are considered, into which it is unnecessary that I should enter at all minutely, inasmuch as I concur generally in your reasoning regarding them, and in the more important of the conclusions at which you have arrived. Whatever may have been the strength of the considerations which, twenty years ago, induced the Government to entrust to guaranteed companies the construction of railways in India, I concur with your Excellency and with the late Viceroy in opinion that the time has now arrived when, both in raising and in expending such additional capital as may be required for new lines in India, the Government should secure for itself the full benefit of the credit which it lends, and of the cheaper agencies which ought to be at its command. Her Majesty's Government has already sanctioned the construction of a line from Lahore to Rawul Pindee on this system, and the preliminary survey for a railway from Carwar to Hooblee. The greater number of the lines indicated by your lordship as of prominent importance (and especially those running mainly through independent native states), are lines to which the new system ought to be applied. The formation of branches and of subsidiary extension of existing lines, where such extensions are of comparatively small extent, may perhaps be more conveniently left in the hands of the guaranteed companies.

"It is, of course, obvious, as pointed out in the 40th paragraph of Lord Lawrence's minute, that the financial success of a railway depends as much on the limitation of its cost as on the magnitude of its traffic, and that, whether Government agency be employed or not, too much attention cannot be paid to economy in construction, to the selection of lines not involving heavy works, and to the careful avoidance of all expenditure not absolutely required for the stability of the works or the accommodation of the traffic. I trust that the direct control of the Government that will be exercised on the state railways will insure full attention being given to these considerations.

"5. In your Excellency's despatch, No. 24, of 11th March, while dwelling on the defective control of the Government under existing contracts with the guaranteed railway companies, you remark, with reference to any new arrangement which should be made with such companies (in 17th and 18th paragraphs), that the simple power of taking over the works from the companies, in the event of their not being carried on to the satisfaction of the Government, would suffice, and be preferable to any special coercive stipulation; and, secondly, you urge that a different system should be adopted in dividing the net profits above the guaranteed rate of interest be dropped as unnecessary. You consider it important that no work, even in extension of their present undertakings, should be entrusted to companies except on these two conditions.

"6. Both of these stipulations are unquestionably right in principle. The first of them ought to be made applicable to all cases, and the second of them to all cases in which the new amount of capital to be expended is sufficient to make it worth while to establish a separate system of account,

"7. To certain portions of the second of your despatches an immediate reply is, however, requisite. In that despatch the following list is given of railway projects which have been suggested for early adoption, and which you consider will, in conjunction with those either already executed or in process of execution, form a network of lines of an aggregate length of 15,000 miles, threading every part of India to which railway communication for the present can be judiciously extended :—

1. Indus Valley.
2. Rajpootana.
3. Kumaon Iron Works.
4. Kooshtee to Darjeeling.
5. East Coast, Northern Section.
6. East Coast, Southern Section.
7. Branches of Madras Railway.
8. Extension of Great Southern of India line to Tuticorin.
9. West Coast, Southern Section.
10. West Coast, Northern Section, comprehending line from Carwar to Hooblee.
11. Mysore.
12. Kulburga to Hyderabad.
13. Junction of North-East and South-East Branches of the Great Indian Peninsula Railway.
14. Branches to Great Indian Peninsula Railway
15. Branches to Bombay and Baroda Railway.
16. Ahmedabad to Veerungaum and Wudwan.
17. Kattywar.
18. Rangoon to Prome.

"8. Of these, Nos. 3, 4, 7, 8, 15, and 16, are considered to be so connected with undertakings of existing companies as to give to the latter a natural hope and expectation that they will be entrusted with their construction, provided they are willing to accept it on certain specified conditions, differing somewhat materially from those of existing contracts. For the remaining projects Government agency would, you consider, be decidedly preferable, and with respect to four of these, viz., Nos. 1, 2, 12, and part of 10, you recommend that preparations be at once made for the commencement of constructive operations.

"9. Thus, with regard to the upper portion of the Indus Valley line, or the part between Mooltan and Sukkur, you desire to have forthwith completed all necessary surveys for obtaining a definite and final project and estimate, on receipt and approval of which executive work might be immediately commenced: while with regard to the lower portion from Sukkur to Kotree, you are anxious that inquiries should be pushed on for determining whether or not it is advisable to combine the excavation of an irrigation canal with the formation of the railway works.

10. In reference to Rajpootana, you are already satisfied as to the course which the line from Ajmere to Delhi should take, and, in anticipation of sanction, are about to have that line at once surveyed, marked out, and commenced, further inquiries being made simultaneously with the view of determining the exact direction of the branch to Agra. You also propose to take early steps for deciding the best direction for a line running southward from Ajmere to Bombay.

11. The line from Kulburga to Hyderabad you also describe as one that should be taken up at once; while for a line from the port of Carwar to Hooblee, surveys are, I presume, actually in progress, under the recent instructions sent by me to the Government of Bombay.

12. The measures which you propose to take regarding the Indus Valley line are approved. It will suffice for the present, to undertake by Government agency the upper section of this line from Mooltan to Sukkur, leaving for future inquiry and consideration the extension of the line to Hyderabad or Kotree. By limiting the work to be performed by the Indus flotilla to

the navigation of the river between Sukkur and Kotree, the communication from Kurrachee to the north-west frontier will be greatly facilitated, pending the completion of the railway throughout the entire length.

"13. Your proposal to take immediate measures for carrying on lines from Delhi and Agra to Jeypore and the Sambur Lake, and from Kulburga to Hyderabad are also approved.

"14. No time should be lost in completing the surveys and investigations necessary for the preparation of complete and reliable estimates, which must be submitted to me in a condensed form before actual construction is commenced.

"15. In the ultimate prosecution of these works, I consider it to be a matter of the first importance that the principle laid down in the 41st paragraph of your despatch, No. 25, should be carefully observed, viz., 'that the actual expenditure on the several railways be strictly limited year by year on a regularly arranged budget estimate to a certain fixed aggregate amount.'

"16. The selection of the lines to be taken up in the first instance must be regulated by this consideration, as well as by the relative importance of the lines, and by the supply of labour to be obtained, without detriment to agriculture or to the progress of other public works.

"17. I recognise the truth of your remark, that it would be 'a mistake to attempt to force on the construction of works of this class in a manner which will seriously increase their first cost;' but I am satisfied that it would be more advisable to confine your operations in the first instance to a few lines, and to carry them out to completion as fast as may be consistent with economy of construction, rather than to commence work on a large number, and so to limit unduly the funds available for each, and to prolong the time during which the capital would remain unproductive.

"18. In speaking of the Rajpootana project, you observe that, whether the connection between Ajmere and Baroda be effected *viâ* Deesa and Ahmedabad, or *viâ* Neemuch, a line from Indore to Neemuch and Ajmere may be indispensable. I am disposed to concur in this opinion, which leads me to the further conclusion that if this link in the communication between Bombay and Delhi be supplied, the extension of the Bombay, Baroda, and Central India Railway into Rajpootana, either by Deesa or by Rutlam, may well be deferred until several more important lines shall have been completed.

"19. Railway communication between Carwar and the interior is, I observe, treated by you in connection with what is termed the northern section of the West Coast Railway, and as if there were to be lateral branches from Carwar north and south along the coast. The utility of such branches is not at all clear to me. I should rather have supposed that, if Carwar was connected by rail with the great cotton field beyond the Ghauts, the traffic of that district would naturally concentrate itself in Carwar, instead of being distributed, as at present, among a number of small rival marts and ports.

"20. Of the projects on your list recommended for construction by Government, the four specified above are the only ones on which immediate instructions are needed. Of those, however, which may be regarded as extensions of the works of existing companies, there are some on which it is unadvisable that decision should be needlessly delayed. Offers shall immediately be made, on the conditions recommended by you, to the Bombay, Baroda, and Central India Railway Company of the proposed extension from Ahmedabad to Veerungaum and Wudwan. And similar offers will likewise be made to the Indian Tramway Company and to the Great Southern of India Railway Company, respecting lines from Arconum to Cuddalore and from Trichinoply to Tuticorin. With reference to your suggestion that lines running parallel to the coast might be preferable to those hitherto proposed, I will only say that it appears to me to be at least doubtful whether railways along either the eastern or western coasts can be among the number of those lines which press for very early consideration. Railways running parallel with the coast must necessarily come more or less into competition with the route by sea, and it would therefore seem expedient that such lines should be deferred until the inland communications have been further developed.

"21. Your excellency considers that a railway in extension of the Eastern Bengal line from Kooshtee to Titalyah at the foot of the Darjeeling Hills, is one which commends itself for early construction on many grounds of policy. Though believing that this line will ultimately be required, I am not satisfied of the priority of its claim to the attention of Government, especially as regards the upper half of the line; but I am prepared to sanction the preliminary survey and estimate of a line from Kooshtee to Bugwah on the Megna, which in itself would be of great commercial value, and would be a starting-point for future extensions to Darjeeling on the one hand, and into the valley of Assam on the other.

"22. On the subject of a railway to the Kumaon Ironworks I addressed you some time ago in a separate despatch.

"23. Regarded as a whole, I may observe generally that the arrangements proposed by you in despatches under acknowledgment appear to me well adapted for providing in India, gradually, regularly, and with all advisable rapidity, a fairly complete national system of railway communication. The success of the arrangements must, however, in great measure depend on the character of the machinery created for the purpose of giving them effect, and I shall be glad to be informed somewhat in detail how you propose to proceed in that essential particular.—I have, &c., ARGYLL."

Upon reference to the map of India (Plate 352), the necessity for the early construction of most of the lines here mentioned will be obvious, but there are a few of them which we think call for further remark. Thus, as regards the Indus Valley Railway, it is said that, "opinion is still divided as to the best line to occupy below Sukkur, and whether the right bank or the left bank of the Indus should be followed;" and, again, "there may be some doubt as to the agency by which this railway should be carried out." In consequence of this uncertainty it appears that a portion only of the "missing link," as it is usually called, is recommended to be commenced at one end only. The vital importance of the speedy construction of this "missing link" will be evident when it is considered that at present the only communication between Kotree and Mooltan is by means of the Indus steam flotilla, the distance by water being about 600 miles. In spite of all the efforts which have been made to render this communication as perfect as possible, the shallowness of the Indus, combined with the treacherous nature of its bed, causes this service, even under the most favourable circumstances, to be quite inadequate to accommodate the demands of Government and the necessities of the commerce engendered, or which should be engendered by the Punjaub Railway system, the average passage between Kotree and Mooltan being 9¾ days for the down, and 20 days for the up trip. As long as the "missing link" is unfinished, it cannot be expected that the Punjaub railways will command sufficient traffic to recoup the Government sufficiently to make up their guarantee; thus leaving these lines, which ought to pay a handsome dividend, a considerable burden to the revenue. There is no doubt that that portion of the "missing link"—the commencement of which has just been sanctioned—viz., from Sukkur to Mooltan, is most needed, as it will obviate the necessity for navigating the worst portion of the Indus, more than a week being occupied at times in passing the first fifty miles below Mooltan. When, however, it is remembered that this portion already sanctioned is considerably more than one half the total length of the "missing link," it is impossible to imagine that the Secretary of State for India would hesitate to sanction the two hundred and odd miles necessary for its completion.

As regards the question whether the line should be made on the right or the left bank of the Indus, or partly on the right and partly on the left—viz., from Mooltan to Sukkur on the left, and Sukkur to Kotree on the right—considerable difference of opinion exists. The proposal to construct the line entirely on the right bank is evidently the most exposed to depredation and interruption from the lawless and unsettled character of the frontier tribes, and consequently for political reasons alone it is most unsuitable. We need not, therefore, take into consideration the engineering difficulties between Mooltan and Sukkur, which would include the crossing of the Chenab and Indus rivers, through the Derajat, and across 80 miles of flooded country between Kusmore and Sukkur. As regards the two other alternatives, viz., whether the railway should be constructed wholly on the left bank of the Indus, or on the left bank from Mooltan to Sukkur, and thence on the right bank to Kotree, we think that either from a political, commercial, or engineering point of view the left bank is superior. The objections already made with respect to the propinquity to the frontier tribes, must still be urged against the right bank scheme from Sukkur to Kotree. With regard to the commercial features, there appears to be some difference of opinion as to the amount of local traffic on the two sides of the Indus, but as the through traffic on the "missing link" would be so enormously in excess of any local traffic, it is evident that the shortest line would be the best, and a glance at the map will at once decide the question in favour of the left bank. With respect to the engineering considerations, we have the eminent authority of Mr. John Brunton, C.E., who, in his report upon the respective routes, after characterising the right bank route in its entirety a "gigantic blunder," shows that the route on the left bank would be 35 miles shorter than that on the right, and cost over £1,000,000 less money. The crossing of the Indus he also shows would be attended by far less difficulty at Kotree than at Sukkur, at the former place the piers of a bridge could be founded without excessive cost, and there is nothing to compel an extraodinary span for each opening, while at Sukkur the inevitable magnitude of the span of the principal opening, viz., 600ft., renders it a formidable undertaking. Besides the vast difference in the width of span, the Sukkur bridge would have to be erected 70ft. above high flood level, but as very few boats pass down below Kotree the headway need not be more than 15ft. above high flood level, with a swing span for the occasional passage of steamers. Col. Phillips, when Deputy Collector of Sehwan and Kotree, reports upon the difficulties to be encountered on the right bank as follows:—

"1st. The liability of portions between Kotree and Omurpoor and between Futtahpoor and Rookun, to inundation, both from the river and the hills.

"2nd. The Lukkeo Pass, a range of hills which cannot be avoided, and about six miles in length, greatest height, say, 1,000ft.

"3rd. The following large hill streams and rivers requiring bridges:—1st. The Mohun, a hill stream with deep sandy bottom, near Sunn, Talooka, Mahajunda, and about 400yds. wide. 2nd. The Arul river at Sehwan, 100yds. wide, never dry. 3rd. The Phitta Canal, in two places; the first requiring a bridge of 85ft., and the second of 65ft. waterway.

"4th. The Fattahpoor and Rookun depression, about six miles long, always inundated to a depth of from 4 to 6ft., and requiring an embankment the whole way; minor water channels, canals, &c., are of course not mentioned."

With regard to the left bank scheme, with the exception of the bridge across the Indus at Kotree, there do not appear to be any engineering works of any magnitude, as the line would traverse a level country, but sufficiently elevated to be above the flood level of the Indus. The only objection which can reasonably be urged against the left bank is the probability at some future period of making a line from Sukkur to Jacobabad and Dadur to intercept trade from Central Asia. How long it may be before this branch is constructed, or whether it will be made at all, we will leave out of the question, but supposing it to be constructed, there would be no difficulty in having a steam ferry across the river to a station at Rohree, above the Sukkur Pass.

From these statements it appears that whether the question is considered from a political, commercial, or engineering point of view, the left bank is decidedly superior to the right bank of the Indus, for the formation of the "missing link."

Darjeeling railway, Kooshtee to Titalyah (210 miles).—The necessity for establishing a line of communication between Darjeeling and the North-West Provinces of India, also between Darjeeling and Calcutta—the one for political, and the other for commercial purposes—is admittedly very great, but the reasons for choosing the route here mentioned is not so obvious. In the adjourned discussion on the subject of the "waste lands in India," which took place at the Society of Arts, on the 21st of May last, Mr. T. Login, C.E., recommended a line which was to start from Rajmahal crossing the River Mahanuddee at Maldah, where it has a deep well-defined channel, and then passing up between the drainage of the Ganges and Brahmapootra to Darjeeling. By this means advantage is taken of the East India Railway, which is already made for nearly half the distance, while with the exception of a small portion of the remainder, it offers no engineering difficulties. This portion, of about 15 or 20 miles has a river, or rather a creek, which is navigable for nearly five months in the year, while the Ganges is in flood. As the Ganges is at that time about five miles broad, and as a steam ferry would at all times be necessary, the steamers could run up the whole distance during the floods. At other times there would be no difficulty in running over the natural soil, which is practically level. If Mr. Login's theory of the abrading and transporting power of water be correct, there would be no danger to the railway in a flood, even if it covered the rails. It is evident that if the water can flow through fields of rice without injuring them, as is the case in this district, it cannot do any damage to the rails, and therefore the line might be constructed very cheaply.

With respect to the extension of the Eastern Bengal line to Kooshtee, near Pubna, we fear there would be great engineering difficulties owing to the peculiarity of the effects of the monsoons on the rivers Brahmapootra and the Ganges. For instance, the rains which begin on the Arracan coast early in May, run along through Assam in June, and along the south of the Himalayas about the middle of June, and consequently the Brahmapootra is in flood long before the Ganges. From this circumstance it is found that at one period of the year the Ganges actually flows backwards in consequence of the rise of the Brahmapootra, and has to escape through the numerous outlets in the delta. On the cessation of the floods in the Brahmapootra the Ganges has about attained its maximum height, and remaining in flood long after the Brahmapootra has subsided, continues its course, or forces its passage eastward, across the Brahmapootra into the Bay of Bengal. This is well illustrated in a very able and interesting paper "On the recent changes in the Delta of the Ganges," by Mr. Fergusson, which was read before the Geological Society (Quarterly Journal, 1863), and from which, in order to establish our position, we take the liberty of making the following extracts. Thus in speaking of the original bed of the Brahmapootra, he says, "we know, that though a considerable body of water may flow that way in the rains, yet during nine months in the year a creek, or rather a chain of ponds 100ft. or 200ft. wide, and everwhere fordable, represents the river, that a little more than half a century before flowed through that country in seven-mile reaches, and with a breadth of more than a mile and a half, even in the dry season," showing the enormous change to which this part of the country is still liable. Again, when treating upon the river Jennai, Mr. Fergusson, when considering the changes of its course in this locality, rather quaintly says:—"In the meanwhile the river is nearly where it is shown upon the map, but it is never exactly in the same place for two successive years, being young and active, and roaming through a new and unconsolidated country. It may also be mentioned that the city of Surajgunge—the largest and most important mart in that part of the country—is somewhere in that neighbourhood now, but not where marked on the map, of course, as it is annually obliged to accommodate itself to the vagaries of the stream and change its locality. It may be ten miles further down, or five miles further east or west; but it is somewhere thereabout; and that is all the information geographers can hope for in a country where land can only be classed with floating capital." When treating upon the behaviour of the Jessore group of rivers at the time of the monsoons, Mr. Fergusson says, that near the junction with the Ganges and the Brahmapootra, one river sometimes has the advantage, nearly driving the other out of its course:—"For the first month of the inundatation the water of the Ganges above Jaffergunge almost flows backwards, and the Echamuttee at Pubna flows into the Ganges, instead of out of it; and during this season the deposit is very considerable. But during the last month of the rains, when the waters of the Brahmapootra have nearly run off, the immense body of water spread over the vast plains of Hindostan rushes into the partially deserted bed of the Brahmapootra, which then acts as a waste water reservoir, and with a force that to a great extent clears out the deposit of earlier months, and so restores equilibrium." "This has been so entirely the case of late years, that the Ganges has straightened its course very considerably below the head of the Jellinghy. The first result of this was to cut off a great six-mile bend on the left bank, *just above Pubna*. This took place some thirty years ago. Within the last two years it has cut off the next bend on the right bank, leaving the *Kooshtee station of the Eastern Bengal railway*, some two or three miles below the head of Gorai, instead of two miles above it on the Ganges, as it originally was, and was designed to be." Again, when giving a description of the neighbouring country, he says—"The fall of the country between Pubna and Jaffergunge is only about 7ft. . . . but if at any time the waters of the Brahmapootra should be 7ft. lower than those of the Ganges, the slope will be doubled; and if 10ft., the scour must be tremendous, and it is believed that this was the difference when the last bend was cut off. Mr. Fergusson also gives an amusing instance of the changes brought about by these rivers to show how fallacious are any conclusions drawn from borings.

He says:—I myself have seen the bricks which formed the foundation of a house I had built, carried away and strewed along the bottom of a river at a depth of 30ft. or 40ft. below the level of the country. Since then the river has passed on, and a new village now stands on the spot where my bungalow stood, but 40ft. above its ruins, and any one who chooses to dig on the spot may find my 'reliquiæ' there, and form what theory he likes as to their antiquity, or my age."

After quoting these examples of the treacherous nature of the soil at the confluence of the rivers Brahmapootra and Ganges, we think it must be evident that although it might with a sufficient expenditure be overcome, the route from Rajmahal would be far superior both as regards cost and convenience. As to the political value of the shorter line, we merely ask our readers to look at the map of India. We have Nepaul on one side of Darjeeling and Bhootan on the other, while most of our military are cantoned in the North-West Provinces and the Punjaub, consequently the shorter line of communication between these parts and Darjeeling should be of importance. It is evident that the line proposed by Mr. Login is several hundred miles shorter than the Kooshtee route for this purpose, as the troops would be obliged to go all the way to Calcutta and thence up the Eastern Bengal line, as pointed out by Dr. Campbell during the conferences held by the India Committee of the Society of Arts. Another advantage is that the Rajmahal line would pass through some of the most populous districts of Northern Bengal, viz., Maldah, Dinajpore, and Purneah, while, by bringing the traffic of these districts to Rajmahal, it would enable this portion of the East India Railway to pay, which at present it is not likely to do, in consequence of the chord line, which has caused this portion to be almost useless in addition to the double expense of the two lines. The necessity for carrying the traffic from Darjeeling and Northern Bengal into Calcutta instead of into Howra on the opposite bank of the Hooghly is difficult to understand. The only difference the Rajmahal route would occasion would be the increasing of the value of property in Howra at the expense of the city of Calcutta, but surely such a consideration could have no weight in comparison with the enormous difference in the probable cost of the two lines. Moreover, it is in contemplation to form a canal of pure water from the Damooda to Howra and its vicinity: when the docks which have long been proposed on the Howra side could be filled from this canal, which would probably make Howra far superior to Calcutta on sanitary grounds. Can it be for this reason that the East India Railway Company have declined to go to the expense of a bridge across the Hoogbly?

The Rangoon and Prome Railway (166 miles) is recommended by the Governor General of India in Council to be put in hand, but no reasons are stated for this recommendation, and we were glad to see that Mr. Grant Duff, the Under Secretary of State for India, threw cold water on the subject. As the Irrawaddy is one of the finest rivers in the East, and is always navigable for large river steamers, and, during the rainy season, for large sea-going steamers for several miles above Prome, it appears absurd to construct a railway nearly parallel to it and through a country which has hardly one-tenth the population per square mile of that of Bengal. When by Mr. Login's articles on "Roads, Railways, and Canals," lately published in The Artizan, it appears that the carriage of goods on the Grand Trunk road for a distance of less than 100 miles is greater than from England (round the Cape) to Calcutta, what would be the difference of cost for bringing goods from China by a mountainous road, and the cost of carriage round by sea? What seems to be required, for the present at least, are foot tracks, or rather bridle roads, in order to open out a communication between the densely-populated portions of China and the rich but thinly-populated districts of Burmah and Assam. This latter route—to Assam *viâ* Cachar—for political reasons would probably be the most easily opened out, as shown by Dr. Barry in the discussion upon "Trade between Assam, Thibet, and Western China," in the interesting conferences of the Indian Committee of the Society of Arts already referred to, and to which we call the attention of our readers as containing much valuable information upon this and various other important subjects relating to India.

## HER MAJESTY'S SHIP "INCONSTANT."

This fine frigate, of 4,060 tons measurement, 1,000-h.p. (nominal) of engines, carrying as her armament ten 12 ton 9in. and six 6½ ton 7in. muzzle-loading rifled guns, mounted on iron carriages and slides—the pioneer of the new type of unarmoured iron built war frigates introduced into the English navy by the present Chief Constructor—has been put through her official speed trial at her load draught of water over the measured mile in Stokes Bay, near Portsmouth, and by the exceptionally high rate of speed she attained more than confirmed the strongly favourable opinions of her powers created by her previous performance on her preliminary trials, and also exceeded the estimate of her speed given in officially to the Admiralty by her designer. The speed trials of the *Inconstant* are without doubt the most important by far of all that have yet been made over the measured mile in this country. She is a war frigate designed for special services, requiring exceptional speed under steam, and in all respects intended for competition with the flying unarmoured war frigates lately added to the American Navy, and whose powers for offence and flight under steam have been so highly eulogised in the official documents reporting upon their trials and handed in by the officers conducting them to the secretary of the United States' Navy. In the American official documents the *Wampanoag* was said to have steamed at the rate of 16·7 knots per hour for 37 consecutive hours, in a strong beam sea and wind, over a given distance along the coast line. This was stated in the reports to have been done by the *Wampanoag*, at her proper seagoing trim, and with all weights on board; but now this is flatly contradicted on this side the *Atlantic*, and the *Wampanoag* is asserted to have attained her extraordinary rate of speed under conditions different from those given in the official reports. It would be of some value to us to learn the exact truth relating to the trials of the American unarmoured frigate, in order that we might obtain some reliable standard by which we could measure the value of our own frigates of a similar character. Sixteen and three-quarter knots per hour continued for 37 hours by the *Wampanoag* is, on the face of the assertion, an almost incredible performance for any ship carrying 15in. guns and exceptionally heavy weights in engines and boilers, unless she was greatly assisted by her sails and, until some precise information be given as to how the distance run in the 37 hours was arrived at, the *Wampanoag* will be only considered really to be what she is asserted to be in this country—a 14 knot ship; and in that case the *Inconstant* is the faster ship of the two by 2½ knots per hour.

On weighing her anchor from Spithead for her trial the *Inconstant* drew 20ft. 8in. of water forward, and 24ft. 7in. at the stern. She did not carry her crew, powder, and shell, and a quantity of stores, but the weight of all these matters was placed on board for the trial in the shape of iron ballast, and, in addition, she carried about 40 tons extra weight in coals, &c., so that her trials were made at a draught of water an inch or so in excess of what it will be when the ship actually proceeds to sea.

Subjoined are the results of the trial. Full boiler power, measured mile runs:—

No. 1.—Speed of ship, 16·901 knots; revolutions of engines—per mile 259, per min. 73·5; steam, 30lb.; vacuum—forward 25·5, aft 25·5.

No. 2.—Speed of ship, 15·385 knots; revolutions of engines—per mile 287, per min. 74; steam, 30lb.; vacuum—forward 25·5, aft 25·5.

No. 3.—Speed of ship, 17,822 knots; revolutions of engines—per mile 252, per min. 75; steam, 30lb.; vacuum—forward 25·5, aft 25·5.

No. 4.—Speed of ship, 15 knots; revolutions of engines—per mile 298, per min. 75; steam, 31lb; vacuum—forward 25·5, aft 25·5.

No. 5.—Speed of ship, 18·367 knots; revolutions of engines—per mile 269, per min. 75·5; steam, 30lb; vacuum—forward 25·5, aft 25·5.

No. 6.—Speed of ship, 14·754 knots; revolutions of engines—per mile 304, per min. 75·5; vacuum forward 25·5, aft 25·5.

Mean speed of the ship under full boiler power, 16·512 knots per hour! Mean revolutions of the engines during the six runs, 74·48 per minute; mean steam pressure, 28·825lb.; indicated power by the engines, 7,343 horse.

Full boiler power circles, 12 men at the wheel:—

To Port.—Half circle made in 3min. 25sec.; full circle made in 6min. 18sec.

To Starboard.—Half circle made in 3min. 11sec.; full circle made in 6min. 10sec.

Half boiler power, measured mile runs:—

No. 1.—Speed of ship, 15·789 knots; No. 2.—Speed of ship, 11·613 knots. Mean speed of the ship under half boiler power, 13·701 knots per hour; mean revolutions of the engines, 59·95 per minute. Mean steam pressure, 14·227lb.; indicated power by the engines, 3,532·29-horse.

Half boiler power circles, 14 men at the wheel:—

To Port.—Half circle, 3min. 56sec.; full ditto, 7min. 50sec.

To Starboard.—Half circle, 3min. 42sec.; full ditto, 7min. 6sec.

The *Inconstant* has a balanced rudder like the *Bellerophon*, *Hercules*, and *Captain*, but in her case the fore part of the rudder was reduced in area very considerably the last time she was in dock, and perfect command is now kept over the ship by the men at the wheel, however far the helm may be put over. On her light draught trial, the vibration on board was found to be very great, but since the ship has been brought down deeper in the water this has been materially lessened, and when the engines were being driven at their highest speed, the vibration exhibited by the hull of the ship was nothing at all extraordinary or beyond what is usually felt under such circumstances. The engines, which were in charge of Messrs. Anderson and Knight, as the representatives of the manufacturers Messrs. John Penn and Son, gave satisfaction in every respect to the Government officials on board.

## IRRIGATION IN THE NORTH-WESTERN PROVINCES OF INDIA.

The report of the Irrigation Department, North-Western Provinces, for the year 1868, shows extraordinary progress. We find that the land irrigated in 1867 exceeded that irrigated in 1867 by 195,000 acres, made up as follows:—Sugar-cane, 11,000 acres; rice, 12,000 acres; Indian corn, 43,000; cotton, 44,000 acres; and miscellaneous, including all inferior grains, 85,000 acres. The increase of cotton is attributed to the market, and that of Indian corn and inferior grains is regarded as proof that the instructions of Government to push that cultivation as far as possible have been kept constantly in mind. Good crops have been raised on nearly 500,000 acres; and 2,000,000 acres have been preserved from pressure of famine. The khurreef irrigation is 64 per cent. more than that of the previous year.

Sir William Muir considers these results highly gratifying. His Honour, in a minute dated the 19th February last, writes as follows:—

"The aggregate result is that there were irrigated from the canals 483,000 acres, which, without this blessing, would for the most part have altogether failed. It is satisfactory to find that the increase has been mainly in food crops not hitherto ordinarily irrigated; cotton is the only exception, showing an increase from 8,000 to 52,000 acres. The addition to the irrigated rice area (from 98,000 to 110,000) is not so great as might have been expected; but this arises from the fact that rice is a crop for which the people, excepting in unusually favourable seasons, invariably use canal water. There remain Indian corn and miscellaneous crops, the area of which rose from 18,307 acres in 1867 to 147,000 in 1868. The area under these heads is especially large in the Etawah division, and illustrative of the rivalry between indigo and food crops in that quarter.

"I wish to have a detail of the figures belonging to the entry 'miscellaneous other crops,' showing separately garden land, bajra, joar, urbur, and such other main heads. Anything bearing on the readiness of agriculturists to use water for the commoner autumn crops is interesting and useful. The considerable area irrigated for this purpose is a hopeful symptom. Although the water was taken too late in some cases to be of any great service, it generally saved the crop, and (as I have myself observed) often produced luxuriant fields both of grain and fodder. It remains to be seen whether the advantages thus secured will lead the people to recognise the benefit, and introduce the practice, of regular irrigation for the commoner khurreef crops; or whether they will, as heretofore, wait on in expectation of the periodical rains.

"The benefits rendered by the canal, both in saving such extensive areas of the more valuable staples, and in giving irrigation to an area (including rice) of 217,000 acres of food and fodder crops, are beyond all calculation, whether we look to the revenue, or, what is of higher import, the saving of life and the general prosperity of the country."

## PATENT LAW.

### The Bovill Litigation.

(*Continued from page* 180.)

"These really are all the questions. I do not think it was intended that you should find a special verdict, as suggested by the counsel for the defendant. A jury are always at liberty to answer the questions point blank, yes or no, which they usually do. They are also at liberty, if they are in doubt in point of law, to find the facts specially; such a course is the one usually resorted to under the present circumstances; and I believe you will best discharge your duty, if your view of the evidence enables you to do so, by answering the questions simply 'ay' or 'no' for the plaintiff or for the defendant; and it is usually found that any "tag," if I may venture to call it so, annexed to the verdict, has an effect probably entirely unanticipated at the time. Yes or no is intelligible; but a special finding very often comes to be misunderstood.

"Now, these being the questions, I refer you to the evidence. The object of Mr. Bovill's patent, as he states it, was to get rid of the moisture between the millstones and also in the meal, in some respects to get rid of the delay, and assist in working the mill, to do away with the unhealthiness which resulted from the dust of the fan and hot moist air getting about the mill; and I think one of the witnesses said the effect was to increase the quantity, if not to improve it also. There was a suggestion as to the improvement of the quality, but that was finally not put in issue; at any rate, there was an increased quantity of flour. Well, with respect to all these, of course you would form your own judgment as to how far Mr. Bovill's patent seems to have gone, and you would do so after the view so ably pointed out on the part of the defendant by his counsel, when he said, 'I don't care for the exhausting of the plenum.' That is his expression,—I call that but an expression; it is only words and wind, and the real question is, whether this process had been applied before so as to produce the results which Mr. Bovill says he gave the means of producing in the year 1849? No doubt the same result may be arrived at by different means in a case of this kind. If by the use of the same mechanical elements you are satisfied that the same result was arrived at before Mr. Bovill's patent was taken out; that it was arrived at not in the way of mere experiment—not in the way of merely happening so that a man was not any the wiser by it in the way of its using it, whether he knew the *rationale* of it or not, does not—appear to me to be material. It is the actual use of the thing, so that anybody about him could see it; I should have thought, if any portion of Her Majesty's subjects knew of it as a thing to be done, and knew how it could be done, it would be evidence from which your mind would probably arrive at the conclusion that the persons who produced those results would produce them by those means. I should have thought, judging from the impression of satisfaction, if such was so, that would be produced upon my own mind, that would be the result at which a jury would arrive. On the other hand, of course, the facts must be clearly ascertained for the purpose of seeing whether there really was any such user, whether there was a user coming up to what Mr. Bovill did, or not.

"With respect to documents, of course, if any documents were in existence in this country before,—and when I speak of this country, I mean in this kingdom, and which a person could get at and inform himself from, so as to do what the patentee suggests that he invented,—if there was a direction enabling him to do it, that would anticipate the patent, although no person might have taken the trouble actually to read it. If it was there as part—to use the same expression which I used before —of the sum of knowledge upon the subject in the country, and capable of practical application, that would do away with the novelty of the patent.

"Perhaps I had better refer to the second class of evidence first, reminding you of the witnesses and the documents, and some of the witnesses who were called to explain the documents. With respect to the documents, it is not my intention to read them through again, but simply to refer to them shortly, reminding you of them, and then go on to what has been stated by the witnesses. First, the French patent, which got into the British Museum in the year 1835 or 1836, long before Mr. Bovill's patent. With respect to that, you remember, evidence for plaintiff, impracticable; evidence for defendant, the plate of the fabric, the tube through which the fan at the top of the small chamber was to suck the meal, or to suck the dust after the meal was delivered up into that chamber, along the flue, would suggest to any practical person to do what Mr. Bovill has done in his third claim. I believe that is about the result. You have heard the statement of the engineers upon that subject. You must take them both, accompanied by this further statement—viz., that that patent does not appear to have come into practical use. Probably you, or some of you, will be able to judge how far that would suggest and point out the means of arriving at what Mr. Bovill did. The next is Damy. As to Damy, I read the specification after going out, and I came back and stated what I thought about the translation of that word *ventilateur*, "blowing-fan," and I must say that I quite unhesitatingly am of opinion that the translation of that word is correct. You have heard the remarks upon it on the one side and on the other; you heard the remark made by the defendant's counsel, that that gave at once the very thing which Mr. Bovill did if a person were a competent person,—which competent person you must always assume in speaking of questions of this description. A child might do nothing, but a philosopher might do a great deal more than an ordinary competent person. You must assume an ordinary competent, skilful person. The remark upon the part of the plaintiff is, that it deals altogether with condensation, and does not at all point out straining as being the object.

"Then I ought to say that the same remark which applies to Damy applies also to Vallod. It does not appear to have got into any practical use. It may be said that millers are slow to take new inventions; yet we know that when persons take the trouble to take out patents, they generally take some means to make them known, and they would find some millers to adopt them if they were really useful.

"Then we come to England. You have Gordon's, which, I think, was in 1844 or 1846."

Mr. Williams.—1844, my Lord.

"Mr. Justice Willes.—Gordon's patent was in 1844, and I may describe it to you in this way: Gordon's was the patent with the blast from below. You recollect what was said as to the effect of the blast without the exhaust, about the blast having the effect of cooling and increasing the working, so far as the working of the stones was concerned, and producing a great increase of dust and stive in the mill, and passing it out into the mill; that was Gordon's blast, which I think I may pass over. Gordon's blast was what was referred to by Mr. Muir. I do not recollect any description of the practical working of Gordon's blast except by Mr. Muir, and I do not think what Mr. Muir stated is at all in contradiction of what was given in evidence for the plaintiff with respect to the blast, and the reason it did not succeed.

"Then you have Newton's patent of 1846, and Newton's of 1846 was the patent the object of which was to exhaust, but to exhaust not in a degree, but altogether to take up the whole produce from the stones as it was ground, and carry it away to a chamber where it was utilized. The effect of the evidence of the plaintiff on that point was to show that the exhaust required was so strong that it caused a waste and carried away the stuff to an extent which made it not a useful patent. The corn was said to be blown through by the strength of the exhaust used in that process, and that was stated not to be a useful process. Now, passing over Newton's patent, we come to Mr. Bovill's patent. Mr. Bovill's patent of 1846 I do not think I ought to make any remark upon. I think Mr. Williams withdrew the evidence given by Mr. Bramwell with respect to the patent of 1846; it is not material except for this purpose, that you should bear in mind that the contrivance shown in that patent unquestionably was given to the world in 1846; these contrivance were given, and that would prevent Mr. Bovill or anybody else from putting them into a subsequent patent except in some new combination with some new result.

"Then there is the Scotch patent of 1846. I do not trouble you by referring to the Scotch patent of 1846, for this reason, because I understood on the part of the defendant that patent was referred to only for a purpose with which I have already dealt, namely, with reference to the question as to No. 1. If it was intended to be referred to for any other purpose, and I am reminded of it, I shall be glad to refer to it. These observations I believe exhaust the documents. I think I have reminded you of all that will at all serve to assist you.

"I have now completed the remarks I wished to make on the documentary evidence, and come to the evidence of the witnesses who were called to prove prior user at various mills; and as I recollect, the mills were four. There was first Mr. Potto Brown, who spoke of two mills, but he spoke particularly of Houghton Mill, at which the process was said to have been introduced at so early a period. He was at Darblay I think he said in 1845, and set about introducing the process in 1846, which he says he has continued in the same way with the results which were described. Now this is a part of the case on which, of course, a vast deal turns. Still even the most important matter which is required to be repeated loses by being stated too often, so I shall refer you at once to the plan which was shown to Mr. Brown as a compendious way of bringing before you the effect of his evidence, assuming you have taken it as being accurate, and as giving the fact as to what was used during the time he speaks of. With respect to this plan and the other plans which I allowed to be shown to the witnesses for the purpose of conveying to you in a compendious way their evidence, I must observe that these plans were not made at an early time, with the exception of that produced by Mr. Muir, whose evidence I shall presently put out of the case, as it does not throw any light upon the process. The other plans were not made at the time, but were made for the purpose of showing to the witnesses. I suppose the real explanation of the way in which these plans were made was by a description from the witnesses, and getting some competent person to put down plans from the description, so that it might assist the Court. That certainly was not evidence of anything existing at the important time which it purports to represent, but it does furnish a means of compendiously, by a leading question, giving the answers of the witnesses. The lower part I may pass over. You have seen this plan before; the lateral tube leading to the side of the room, and the contrivance there, has not been described, and I suppose, therefore, it was not thought important. It is apparently like a valve; but I pass it over. Then there is the ascending shaft to the middle room, in which middle room the fan was said to work. Then there is the upper room, in which the curtain was placed. That curtain was described by two of the witnesses as being fastened at the top and at the side; by all the witnesses, if I recollect right, and certainly by two of them, who spoke with respect to this plan, it was described as having the means of being fastened by loops at the side at which it was not fastened to the wall, and in the same way, one of them said, to the floor. The third witness stated it to be a curtain which hung from a rod near the top of the room, on which it moved across upon rings. That is the description you have of the curtain. If you desire it I will read over the evidence of Mr. Potto Brown."

A Juror.—It is perfectly unnecessary, my Lord.

"Mr. Justice Willes.—I have selected certain matters which I think ought to be taken into consideration in dealing with that evidence. It struck me at the time, and I made notes to which I have referred and taken out shortly those matters. Now the witnesses were Mr. Brown himself, Clarke the millwright, and King. Clarke was a millwright and owner of a mill also. King was at the mill, and they all spoke of its being put up so early and of its working. With respect to the curtain, Mr. Brown made a statement which is not unimportant I think, with reference to the third part of the claim, that the curtain was not always down, but at times it was looped up, according to the state of the weather. If it was tied up, the effect would be that the air would pass out through the cowl, but the curtain was there, and it was described to have the effect which Mr. Bovill attributes to his machinery in the third claim. That was Mr. Brown's statement with respect to the curtain. I think it also appears that Mr. Brown in the year 1851 had a communication with Mr. Bovill on the subject of a license, and it is not wrong to remark that in 1851 he acted in a manner as to which you will say whether it was the manner of a man who asserted that a person had wronged him by taking out a patent for a thing which he had been doing since the year 1846, or whether it was the manner of a man who thought that he himself had not quite come up to the thing, and that Bovill had got something as to which he must come to terms with him, It is very material, because Mr. Brown appears to be a very substantial man, quite master of himself and able to take care of himself, and all his evidence was that of a strong man, and not the sort of man who would be likely to give way if he were quite certain. That is only a remark upon his evidence, still it would be wrong if I did not mention it, because it produced an impression upon my mind. Mr. Brown explained it by saying that he did not want litigation, and therefore wished to get the license, but did not choose to take one out. Then follows the proceeding; but to that at this time I do not propose to make any reference.

"Clarke was there, and he was the millwright who put it up. The only remark upon Clarke's evidence that I shall make is, that he appears to have been the owner of mills; he does not seem to have put up this, which, if it were Mr. Bovill's invention anticipated, would seem to be a very useful thing in anybody else's mill or in his own. He made an application to put it up. When those applications were made, I have not made a note of. Given utility, ascertained in 1846 by an apparatus put up and known by Clarke, who afterwards became a millowner, not made for others or put up by him.

"Now with respect to King's evidence that only brings in that it was stated, that in that place in which Bovill's No. 3 is alleged to have been anticipated by a curtain room, the stive which was taken from the floor was stated to have been given to the pigs. I shall read over the evidence of those witnesses, or either of them, if you wish it; but I thing this plan is quite a sufficient reminder of what it was.

"The next person who was called was Mr. Fison. The rebutting case also referred to Fison; but inasmuch as Fison stated it in his own evidence, I do not think it necessary to refer to the rebutting case upon that point. Fison appears to have put up a plan which is said also to have been an anticipation of Bovill's. That plan he kept for some months, and then he adopted Pinel's process, which turned out to be unsuccessful; he abandoned Pinel's process, I think, in 1849, and from that time to 1851 or 1852 he did not resume the use of that which is said to be an anticipation, so as to make it an anticipation. Therefore you have the application of the thing for a short period abandoned, a substitution of something which did not succeed,—that of Pinel's; that given up. A man, therefore, whose mind is on the subject of improvement, desirous to adopt it, and who, if the first was so very great an improvement as it is suggested it was, that is to produce the useful result there was in Bovill's, what would he have done,—would he have resumed it or not? He did not resume it for three or four years, and when he did, he resumed it with a difference, that is, after the date of Bovill's patent. Mr. Fison's evidence is corroborated by Mr. Rafle's and Mr. Pung's evidence in the rebutting case. Fison's and Rafle's were the evidence as to this mill.

"With respect to Mr. Muir, I do not propose to make any remark. If he used what he did use during the time, he used it with Gordon's blast. As the counsel for the defendant stated he would not make any remark upon Mr. Muir's evidence, it would be wrong that I should deal with it, unless you desire to have it read over. That seems to have disposed of the evidence of Mr. Muir and Jameson as to the Glasgow mill.

"Now we come to Kidd's mill, and I believe that is the last mill with which I shall have to deal under this head. Kidd's mill at Isleworth appears to be a very large establishment, and to have been so during a period extending over all the time with which we have been dealing in this case, or a greater part of the time. At Kidd's mill a contrivance is stated by the witnesses to have been applied successively, with some differences and changes, to the three sides of the mill acted upon by three fans, as to the precise position of which at first there is a variance, probably accounted for by the fact that the evidence for the plaintiff shows a change in the position of two of the fans,—the fans stated to have been on the floor above the stone floor, and at the roof, with the enclosure of the bin by the fabric, which fabric was taken away at one period, and boards substituted for it. A change was made in the year 1856, which on the part of the defendant is stated to have been not an important one, with reference to the working, and what was done before the patent of 1849, but which he witnesses called in the rebutting case on the part of the plaintiff is stated to have produced a very considerable result, both with respect to the state of the meal and the state of the stuff, which was removed not in the state of the stive, because the witness who spoke to that corrected himself and said there was no machinery in operation when he went to put up the alterations of 1856. There his evidence stated not that there was a quantity of stive with the old process, but that the old process had been removed when he put up the other. That seems to have been the course of the evidence. I omit the interludes as to putting up boards where there was the order for inspection. Mr. Podger's evidence as to that was, that boards were a ready substitute for canvas, and the application of the canvas is still important.

"Now with respect to the evidence given by those witnessess, who were many in number—Raymond, Mather, Westwood, and Podger—Mr. Kidd is said to be too old to attend: he is said to be eighty years old. The circumstances to which I think I intended to call your attention, with respect to that evidence were the changes in 1856, the state of the floors, the description given by the witnesses with respect to the paste, the removal of the canvas, and the boards put up. Mather was the name of the witness who spoke to the blast going up the mill-pipe. That is the evidence referred to, I think, by Mr. Williams."

Mr. Williams.—A gentle draught going up the mill-pipe, my Lord.

"Mr. Justice Willes.—I have not got the word "gentle," but no doubt the learned counsel is right; but one would as soon take counsel's note as one's own.

A Juror.—Is that the millwright, my Lord?

"Mr. Justice Willes.—He said 'a gentle draught.' The evidence on the part of the Kidds is to the effect that the process was used there, which combined an exhaust with the porous fabric; that going on during all the period, but negativing the materiality of the change in 1856. They say it dated from the time when it was erected before the patent, and produced the same result which Mr. Bovill's patent produces. Now there is one thing which I have omitted in speaking of Mr. Fison's evidence, and which I ought not to have omitted. Mr. Fison spoke of having tried the strainer upon the dressing-machine before he took it in the mill, and with success. He says that shows the use of the strainer in an analagous way. It excludes the idea of novelty. The evidence as to the meal he treated as an experiment. I shall rather classify the two together, and treat both as experiments. A distinction was made in that respect on the part of the defendant. True it is that a man cannot take out a patent for a new form, any more than if a valid patent is obtained, can the infringer defend himself by saying that what he has done is done in a new form, provided the substance of the patent is infringed. A man cannot take out a patent for a new form of a thing which was known before; he cannot take out a patent for making a thing known before, of a material not known before without producing any further beneficial result; he cannot take out a patent for applying an old tool or contrivance to an analagous use to which it was applied before. That is the application which it is said ought to be made of Mr. Fison's evidence as to the dressing-machine, if not as to the mill. You will consider how far you are induced to draw a distinction, and if you admit it, you will say so by your verdict. The use of that strainer in that case being to get rid, as I understand, of the dust in the dressing of the meal, and the use of the strainer in Bovill's case being to collect and utilize flour which otherwise would go to waste if it were not caught by the strainer. I have now got to the end of that evidence. There was a good deal of other evidence upon the one side and upon the other, but I believe I have in substance reminded you of it. I allude particularly to the scientific evidence, if one may call it so, given on one side, and on the other. Far be it from me to depreciate the evidence of that description, and hope I am not so foolish as that; and if I appeared to interpose, it might have been a little hastily or tartly when Mr. Bramwell gave his evidence, you may depend upon it it was not out of my want of respect or regard for that gentleman. I do not think it necessary to read over that class of evidence, either upon one side or the other to you. I believe there is only one other point which has weighed upon my mind, and which I must divest it of. We are dealing with and testing whether things are the same by comparing the results. On the part of the plaintiff it is said,—'I was on the look-out for the invention, and I never 'found it before the patent of 1849.' On the part of the defendant it is said,—'Be it so, but other people were.' And no doubt they were "upon the look-out for it," and it was discovered by one or more of them, and we shall prove that by our witnesses, by showing that they attained the same result which you allege to be the benefit flowing from your alleged invention.

"In comparing results, it would be wrong not to refer to the specimens which were produced on the one side and upon the other, of the actual stuff that comes from the screen. On the part of the defendant you recollect that a man was called from, I think, Christie's Mill, where this is in operation, and he produced two papers of the damp and foul stuff, which he states he got—damp, white stuff from just outside the fabric, between that and the boards in which it is enclosed, leaving a small space between; the other dark stuff from the walls, that is, from the boarded walls as I understood him, and the windows of that room. Then the other specimen which has been produced in rivalry of that, is the specimen produced, I think, yesterday morning, from the mill; the other, at which the process of Mr. Bovill is applied and the state of which you saw for yourselves. I do not think it is right that I should myself express any opinion upon those specimens without going to look at the thing for ourselves; but it would not be right to omit, as it was relied upon on one side and the other If there is any other matter which on either side it is thought—I do not mean details of the evidence, because I shall not read through my notes, or read any of these documents over again, unless you desire it—if it is thought I have omitted any head, I shall be very glad to supply it. That appears to me to be the conclusion of the matter as far as I am concerned.

"Perhaps we ought to look at the process of 1849. I forget the exact date."

Mr. Williams.—June, 1849, my Lord.

"Mr. Justice Willes.—Taking it that Mr. Bovill, in June, 1849, got from the Crown a grant of a proceeding, leaving out the first and third, upon which I have said all I have to say, by way of applying a new idea that the proper way of using the exhaust upon mills was to regulate the blast so as to make the drawing away equivalent—I was going to use a long word, to an "equilibrium," though possibly you could not get the exact equality, though for practical purposes you would get an equivalent, because you could apportion it to the blast that entered, supposing he discovered that idea and the mode of applying it, he secured that patent to himself, producing thereby beneficial results. The question for you, gentleman, is, was that, in your judgment, a thing that had been made out by another or others before that date? The same question with respect to each of the other parts of the case. To put that more at large, a similar question with respect to the other parts of the case, because it seems to be a point upon which the greatest stress of the evidence bears. I do not think I need tell you the exact form in which the issues are put; but I put questions one, two, three, and four. Was number one new? Was number two new? Was number three new? These are the questions. You will consider them for yourselves, and say whether you find for the plaintiff or the defendant."

The verdict was the that the first and 3rd claims were new but that the 2nd claim was not for a new invention.

(*To be continued.*)

## ANNUAL CONFERENCE OF MECHANICAL ENGINEERS AT NEWCASTLE.

### Address of Sir William Armstrong, President.

This year is the centenary of the steam engine of Watt; and I am glad that it has fallen to the lot of Newcastle to receive, on so auspicious an occasion, a society which must regard Watt, more than any other man, as the father of their calling. First, then, I shall discharge my duty as your President by paying a tribute of respect to the memory of the illustrious man who, in the corresponding year of the last century, completed and set to work the greatest of mechanical inventions. In 1765, the authorities of Glasgow College, little thinking of the momentous step they were taking, intrusted a model of a Newcomen engine to James Watt, a maker of mathematical instruments, for repair. The sagacity of Watt enabled him, by an inspection of the model, to detect a radical defect in the principle of the engine. He saw that the condensation effected within the cylinder reduced its temperature, and rendered restoration of the wasted heat necessary at every stroke. He perceived that the steam ought to act in a vessel always hot, and be condensed in a vessel always cold. He thus conceived the idea of separate condensation. With a quiet tenacity of purpose he set to work, under great disadvantages, to realise his idea of a more economical steam engine. His design was soon matured, but the difficulty of execution long remained a barrier to practical success. In the Newcomen engine, the weight of the atmosphere, acting against a vacuum, was the moving power, and leakage of air past the piston was prevented by water resting on the upper side. An unbored cylinder, made in separate parts, sufficed for this arrangement, but in Watt's design, steam instead of air acted on the piston a water packing was inapplicable; and leakage could only be prevented by the more accurate fit of the piston in the cylinder. A moderately steam-tight cylinder and piston were, however, more than the workshops of the day could produce, and we read of his vain attemps to correct, by pasteboard and cork, inaccuracies of workmanship, such as in our time have no existence. With ailing health, narrow pecuniary means, and a temperament inclining to despondency, he was, in many respects, unfitted for a struggle with difficulty; but he was a man whose mind was taken captive by an idea, and he could not help persevering. His attractive character and fine intellect had attached to him many valuable friends, superior in station to himself, and his letters to some of those friends, written during his struggles, exhibit at once his discouragement and his irresistible impulse to proceed. In 1768, he had succeeded in producing a condenser with its necessary appendage of an air-pump, but it was not until the following year —1869—exactly a century ago—that his first complete steam-engine was finished and put in motion. The first trial was made by Watt in a secluded glen, behind the house of his friend, Dr. Roebuck, near Linlithgow. The engine was not a mere working model, but a machine of considerable power. It had a cylinder of 18in. in diameter, and a stroke of five feet; but the cylinder and piston, which were described as the best the Carron Ironworks could produce, were still so inaccurately made as to defeat, in a great measure, the anticipated success. The engine, however, afforded a practical demonstration of the value of the invention sufficient to lead eventually to the happy alliance of the capital of Boulton with the genius of Watt. In 1773, the engine was removed to Mr. Boulton's works at Soho, and was fitted with a new cast-iron cylinder, the casting and boring of which were deemed no small achievement in those primitive days of mechanical engineering. This first engine of Watt was, like that of Newcomen, only applicable to pumping, but Watt quickly saw by what modifications it could be rendered available for rotative motion. By a succession of brilliant inventions, comprising, amongst others, his parallel motion and his ball governor, he advanced to the final conception of the double-acting rotative engine, which became applicable to every purpose requiring motive power, and continues to this day, in nearly its original form, to be the chief moving agent employed by man. To do full justice to the genius of Watt, we must consider the disadvantages under which he laboured. In the present day, every contrivance is practicable in a constructive point of view, and the vast variety of devices used in modern mechanism, and applicable to new mechanical combinations, are made known to inventors in minute detail by the press. But Watt had no such facilities. He had to draw from his own mind what we can now choose from pre-accomplished invention, and his choice of means was restricted to the narrow limits of what was practicable in the rude workshops of the period. If we give due weight to these considerations, we shall be able to appreciate the remarkable originality of his mind, and the sagacity displayed in his invention. Watt lived to see his steam-engine bear fruit in marvellous utility to the human race; but he could have had no idea of the results it was destined to realise before the first century of its existence. It is impossible to contemplate these results without feelings of enthusiasm. To appreciate how much we owe to the steam-engine, we need only consider for a moment what our position would be if we were deprived of its agency. The factories which clothe all the nations of the earth, would be almost extinguished. The deep mines which supply nearly all our mineral wealth, would be abandoned. The manufacture of iron would shrink into comparative insignificance. Horses and sailing ships would again become our only means of transit. All great engineering works would cease, and mankind would relapse into that condition of slow and torpid progress, which preceded the subjugation of steam by Watt. Having thus in honour of an inventor, whose name will grow greater as the world grows older, referred, in general terms, to engineering progress during the last hundred years, I need but glance at some of the more recent achievements in mechanical and constructive art, in order to show that the extraordinary advance of the century continues unabated. That such is the fact, will at once be apparent, when I remind you that during the short period of eleven years, which has elapsed since the Institution of Mechanical Engineers last held their annual meeting, in this town, the Atlantic Telegraph Cables, the Suez Canal, and the great railway across the American Continent, exceeding in length the sea passage from Europe to America, have been added to the engineering triumphs of the century. Of these, there is but one of which England can claim the glory, and that is the first successful Atlantic telegraph. The recondite science involved in that undertaking, the boldness of the enterprise, the perseverance displayed after the first failure, and the moral effects, as yet but partially developed, of its ultimate success, justify us in regarding the first Atlantic telegraph as one of the very greatest and most honourable achievements of man. But Englishmen may feel additional pride in reflecting that the successful laying of that cable, as well as of the subsequent French one, just now completed, was chiefly due to the fact that there had been previously completed in this country a steamship of such gigantic size as to be of itself one of the greatest wonders of modern engineering. Thus it is that one great invention hangs upon another. First came the steam-engine, then followed the great steamship, and finally the Atlantic cable, which, without the aid of steam, could never have been laid. The Suez Canal presents another example of the direct application of the steam-engine to the execution of one of the most remarkable of modern works, the chief part of the Suez Canal having been executed by steam dredgers, of which an interesting description was received by this institution at the Paris meeting. In contemplating this undertaking, we are naturally led to compare it with the great neighbouring relics of Egyptian antiquity. In quantity of material moved, the Suez Canal is far more vast than the great Pyramid. In its moral and intellectual aspect it is immeasurably superior. The ancient work is a useless monument of the idle vanity of a tyrant; the modern work will bear witness to the practical science and utilitarian spirit of our better times. Surely the world improves as the dominion of mind over matter is extended. I should lengthen my observations too much if I were to review the many new and important applications of machinery and mechanical processes effected since our last meeting here. The manufacture of iron and steel—steam cultivation--mining operations—steam locomotion by land and water—economy of labour and of time—economy of fuel —printing—and even the humble business of the sempstress, have all been facilitated and promoted by recent mechanical progress. The subject of coal follows, naturally, a notice of the steam-engine, and has a special interest for us, in a locality celebrated, since the earlist days of coal mining, for the production of that invaluable mineral. England, with her innumerable steam-engines and manufactories, is more dependent upon coal for the maintenance of her prosperity than any other nation, and the question of the duration of her coal fields now very properly occupies the attention of a Royal Commission. The investigation of the Commission are not yet completed: but so far as they have gone, the results are reassuring. I concur in the probable accuracy of the announcement lately made by two of my fellow-commissioners, that the total quantity of coal in this island will prove to be practically inexhaustible; but until the complicated details of quantities collected by that Commission have been put together, and expressed in totals, it is difficult to judge with certainty or accuracy on the subject. Although the duration of our coal may, geologically speaking, be practically unlimited, we have still to consider the important question, how long will England be supplied with coal as good and as cheap as at present? We have unquestionably made greater inroads into our best and most accessible coal beds than other nations have done into theirs; and if foreign coals should grow better and cheaper, and ours dearer and worse, the balance may turn against us as a manufacturing country long before our coal is exhausted in quantity. It is clear that our stock of good coal is very large; but most of it lies at great depths, and one of the most important questions the Royal Commission has to investigate is the depth at which coal can be worked with commercial advantage. The chief obstacle to reaching extreme depth is the increase in temperature which is met as we descend. I am justified by ascertained facts in saying that this rate of increase will, as a rule, prove to be not less than one degree Fahr., for every twenty yards in depth, and there is reason to expect that it will be even more rapid at greater depths than have yet been attained. The constant temperature of the earth in this climate at a depth of 50ft. is 50°, and the rate of increase as we descend is to be calculated from this starting point. Adopting these figures, you will find that the temperature of the earth will be equal to blood heat at a depth of about 980 yards, and, at a further depth of 500 yards, mineral substances will be too hot for the naked skin to touch with impunity. It is extremely difficult to form an opinion as to the maximum temperature in which human labour is practicable, in the damp atmosphere of a mine, and it is almost equally difficult to determine how much the temperature of the air, in the distant parts of an extremely deep mine, can be reduced below that of the strata with which it is brought in contact. It is certain, however, that the limit of practicable depth will chiefly depend upon the mechanical means which can be provided for relieving the miners of the severest part of their labour; for maintaining a supply of sufficiently cool air at the working faces of the coal, and for superseding the use of horses, which suffer even more than men from highly heated air. For the relief of labour we must look to coal-cutting machines; for improvement of ventilation to exhausting fans; and for the superseding of horses to hauling engines driven by transmitted power. The employment of coal-cutting machines, worked by compressed air, conveyed into the mine by pipes, is already an accomplished fact, and when the difficulties and the objections which usually adhere, for a considerable time, to new mechanical arrangements are removed from these machines, they will probably attain extensive application. One of the earliest attempts at coal-cutting by machinery was described by the late Mr. Nicholas Wood, at the former Newcastle meeting of this institution, and all the really practical results as yet obtained date from that period. The cooling influence of the expanding air as it escapes from these machines will be a collateral advantage of considerable importance in the hot atmosphere of a deep mine. The air discharged from the pneumatic coal-cutting machines now in use in the Hetton Colliery, escapes into the mine at a temperature of seven degrees below freezing, and the cold air from each machine appears to be sufficient in quantity to lower the temperature of the circulating atmosphere by one degree. If, as seems to be probable, six or seven of these machines can be employed at each working face, we may by this means lessen the heat by a corresponding number of degrees, and thus afford very considerable relief. The employment of compressed air, as a motive power, in substitution of horse traction, is also quite feasible, and may be expected to become quite general in very deep workings. As regards ventilation, the fan machines of the several constructions tried have already exhibited great superiority over the old method of ventilating by an upcast furnace shaft; and although the efficiency of the furnace system ventilation is increased by depth, there is reason to believe that the fan will maintain its superiority to greater depths than are likely to be reached in mining. Thus far I have spoken of mechanical engineering as applied to purposes of production. I have now to refer to it as connected with the opposite element of destruction. When battles were fought hand to hand, war, so far as mechanics are concerned, was an affair of muscular force, and was in that form the most sanguinary, because combats were the most close. When other forces were called into play, inventive appliances became necessary, and these, as they have advanced, have more and more widened the distances separating combatants, and have thus operated to prevent that greater sacrifice of life which would otherwise have resulted from the employment of more destructive weapons. It is, therefore, not to be supposed that future wars will be rendered more murderous by the intervention of the engineer; on the contrary, we may fairly anticipate that the more the element of intelligence supersedes that of animal force in military struggles, the more will the barbarity of war be mitigated. Science naturally sides with civilisation, and tends to establish a supremacy over barbarism, and we find this tendency, as in the case of the late Abyssinian war, not only giving overwhelming superiority to the cause of civilisation, but deciding the issue with the least possible waste of life. But whatever our sentiment may be in regard to war, it would be absurd to contend that we ought to withhold from invention when the object sought to be attained is the destruction of life and property. It is our province, as engineers, to make the forces of matter obedient to the will of man, and those who use the means we supply must be responsible for their legitimate application. It will be in the recollection of the members of this institution who visited the Elswick works on the occasion of the last meeting at Newcastle, that two or three small breech-loading rifled guns were shown to them as novelties deserving their attention. Those guns had very recently received the recognition of the British Government, and may be regarded as the small beginning of a system of ordnance which has since attained a very extensive adoption in this and other countries. It was not until the principle of rifling was adopted for military fire-arms that these weapons presented much scope for the mechanician's art, but the introduction of rifling, and the change in the form of the projectile, from a sphere to a pointed cylinder, brought about a complication of new conditions which it has required years of research and experiment to meet and satisfy. Passing over the subject of rifled small arms, which of late has called forth a great amount of ingenuity and skill, I will speak of artillery, as being that division of gunnery with which I am personally connected. The most important of all the considerations affecting modern artillery is how to obtain the strongest possible tube with the least possible weight. Before I state my views as to the best mode of attaining this object, I must call attention to the conditions affecting the force to be resisted. When a charge of powder is fired in a gun, it is converted into gas at an exceedingly high temperature, and the pressure exerted is due, even in a greater degree, to the heat than to the quantity of gas produced But the heat evolved is not wholly realised in augmentation of pressure, a considerable part of it being absorbed by the material of the gun. The heating of a gun by firing is an effect familiar to every one, and it affords an indication both of the quantity of heat abstracted from useful effect, and also of the amazingly high temperature of the gas before it escapes from the gun. Fifty rounds fired in quick succession from a field-piece will make it so hot that it cannot be touched. Since the flame is only in contact with the bore for about the 150th part of a second at each discharge, it follows that the aggregate duration of the flame contact by which the gun is thus heated, in fifty rounds, only amounts to one-third of a second. The thin film of heated matter deposited on the surface of the bore at each discharge contributes, in some measure, to this rise of temperature; but we may regard the acquisition of heat from this source as fully neutralised by the cooling of the gun in the intervals occupied by loading. Thus, then, you will be able to appreciate both the intensity of the heat of the gas and the extent of the waste by absorption. In small guns the area of absorbing surface surrounding the charge is greater in relation to the mass of the charge than it is in large guns. Therefore, the waste caused by the heating of the gun is also relatively greater, and the gas never attains either the same heat or the same pressure in the smaller weapon as in the larger. But the greater heat attained in a large gun adds to pressure not only directly, by expanding the gas, but indirectly by accelerating the combustion of the powder. The powder must be regarded as fuel burning in a furnace, and the hotter the furnace is the quicker the fuel will burn. You will perceive, then, that the pressure of powder-gas per unit of surface is augmented by increasing the size of the gun apart from all considerations regarding the projectile. But the pressure of the gas is further increased in large rifled guns by the great length of column represented by thin projectiles. The resistance increases with the length of the projectile, and the pressure rises with the resistance. Augmentation of pressure is also caused by the rifled projectile having to acquire motion of rotation in addition to that of translation, though the increase of resistance, and of consequent pressure, due to this cause is not so considerable as is commonly supposed. For these various reasons, the introduction of the rifled principle, and the enormous increase of size demanded in modern ordnance, combine to intensify that pressure to a degree which taxes our utmost resources to control. The limit of the pressure actually reached in rifled guns of the largest size, when fired with English service powder, is not yet fully ascertained, but it is probably not less than seventy thousand pounds on the square inch. Now comes the question of what construction is best adapted to resist so inordinate a strain. It was long since demonstrated by Professor Barlow that a cylinder, to possess the greatest possible resistance to a bursting force, must, when out of action, have its interior in a state of compression and its exterior in a state of tension. He further proved it to be necessary that the internal compression should diminish in an outward direction, and the external tension in an inward direction, up to an intermediate zone of neutrality. If these conditions were neglected, he showed that in a very thick cylinder the material forming the interior portion would be stretched to the breaking point before the exterior portion acquired any considerable tension. The interior, therefore, would be over-strained, while the exterior would be under-strained, and the aggregate resistance would necessarily be less than if all parts were doing full duty. This reasoning is the foundation of the argument in favour of built-up guns, in which every layer of the material is stretched upon the layers beneath, and the finished structure is in the condition of internal compression and external tension, demonstrated by Barlow to be that of greatest strength. The Americans have endeavoured, with partial success, to realise the advantage of this principle in cast-iron guns, by cooling the inside first, and allowing the external portion of the metal to shrink upon the hardened interior. The Rodman cast-iron gun is made upon this principle, and considering the nature of its material, has, in some examples at least, exhibited great power of resistance, though not sufficient to enable it to be used for heavy ordnance in the rifled form. Where forged material is used for the fabrication of guns, this condition of outward tension and inward compression is unattainable except by the application of the material in successive layers, each stretched on those below. Considerations of economy or convenience may supervene to reduce the number of layers, as in the Frazer modification of coil-made guns; but theoretical perfection will be most nearly reached in that gun which is composed of the greatest number of layers. To attempt to forge large guns in single blocks is a direct violation of established theory, and the general failure which has attended such attempts is a practical proof of the truth of the theory. The next point to consider is the best kind of material for the fabrication of guns. In determining this question, the choice clearly lies between steel and wrought-iron. I say this with no disparagement of Major Palliser's system of adopting cast-iron smooth-bore guns for rifling, by introducing a tube of coiled wrought-iron, but this method has, hitherto, only been applied with success to guns which, though formerly classified as heavy ordnance, are dwarfed by comparison with the ponderous guns of the present day. For these we require the greatest strength we can attain, and cast-iron cannot possibly be regarded as so efficient for enveloping the internal tube as either wrought-iron or steel. In discussing which of these two materials is best, I shall be trespassing on controversial ground. Krupp and Whitworth, both great names in gunnery, though differing widely in their views on other points, agree in this, that steel is the right material for the entire gun. I, on the other hand, have always advocated wrought-iron in the form of welded coil for the chief mass of the gun, limiting the use of steel to the internal tube, which has abrasion to resist as well as tensile strain. The expression of my opinions upon this point may probably not be considered impartial, but I will nevertheless state the grounds upon which my preference of wrought-iron thus applied is based. It had been found both in the Elswick and Woolwich guns, that whenever failure takes place, it almost invariably originates with that part which is made of steel. It is the steel tube which is nearly always the first to crack. So also, when the vent-pieces or closing blocks of the breech loading guns were made of steel their fracture was alarmingly frequent, but since wrought-iron has been substituted such occurrences are rare. The conclusion, therefore, at which I long since arrived, and which I still maintain, is that, although steel has much greater tensile strength than wrought-iron, it is less adapted to resist concussive strain. This conclusion is in strict harmony with the fact that armour-plates made of steel have proved, on every occasion of their trial, greatly inferior to plates of wrought-iron. The experiments which I made some years ago on the toughening of steel, in large masses by immersion, when heated, in oil, led me to expect that this fragility would be obviated by that process, and I felt sanguine that I should be able by such treatment to produce steel armour-plates of extraordinary resisting power. An armour-plate of steel was accordingly manufactured for experiment, and was tempered in a large bath of oil. Its quality was tried by test pieces cut off after tempering, and proved by tension and bending. The results showed a very high tensile strength, combined with so much toughness, that I was unable to match its bending power by any sample of iron I could compare with it. The plate was then sent to Portsmouth for trial, in the fullest confidence of its success, but two shots from a 68-pounder sufficed to break it in various directions, and it was justly pronounced a failure. With these experiences before me, it is impossible that I can hold any other opinion than that the vibratory action attending excessive concussion is more dangerous to steel than iron, and were it not necessary to provide a harder and more homogeneous substance than wrought-iron for the surface of the bore, I should entirely discard the use of steel for the manufacture of ordnance. I do not mean to contend that very strong guns may not be made of steel, but I am convinced that failures will be more frequent, and, I may add, more disastrous, with steel than with iron, when the conditions of trial are the same. The want of uniformity in the quality of steel continues to be another serious objection to its use; and, in addition to all these considerations the element of cost is greatly in favour of wrought-iron coil construction over every mode of manufacture in steel. I will now offer a few remarks upon the interesting question of the probable future of guns. Upon the solution of this question depends the pattern of future ships, and also the policy of continuing or abandoning the struggle of armour-plates against guns. From my previous remarks on the increase of pressure with which we have had to contend as we have increased the size of our guns, it might be inferred that we were now nearly reaching a limit, beyond which the strength and endurance of our material would not enable us to pass. I am not prepared to say how far we could have advanced under the recently existing conditions; but certainly every increase of size would have been attended with increase of difficulty. A new light, however, has just dawned upon the subject, which entirely alters the prospect. It has become apparent that the power which we have been using can be so modified as to produce the required effect, with greatly less strain upon the gun. It may appear paradoxical that there should be a limit to the theoretical advantage of increasing the initial pressure of the gas evolved in the gun, but the apparent anomaly will disappear on examination. The action of expanding gas in a gun is analogous to that of expanding steam in the cylinder of a steam-engine, and we all know the advantage, in the case of steam, of having a high pressure to begin with, provided a steam jacket, be used to maintain the material of the cylinder at a temperature equal to that of the entering steam. But in a gun we can have no provision analogous to the steam jacket, and it would appear that it is owing to the necessary absence of such a provision that there is a limit to the increase of initial pressure, beyond which no gain of propelling force is realised. Perhaps I shall not be fully understood without explaining this curious and important subject in a more definite manner, and I will therefore endeavour to do so. The force exerted in a gun bears a certain relation to the heat evolved by the gasification of the charge. The greater the heat the greater the force, for heat is nothing more than unexpended force. I have already alluded to the loss of heat by transmission to the gun, and it is evident that this transmission must be greatest in amount when the heat of the gas is highest. By using a slower-burning powder, less heat and pressure are evolved at first, and the waste of heat in the stage of initial pressure being less, more heat remains for expansive action. Hence the slower-burning powder is weaker at first, but stronger afterwards, and although the total quantity of gas be only the same, and the pressure not so great at any point, yet the aggregate pressure throughout the bore may equal that of the more energetic and more dangerous powder. This would not be so if the gun, like the steam-jacketed cylinder, could be maintained at the maximum temperature of the elastic medium within. But in the case of the gun that temperature would be far above the melting point of its own material. It is only lately that attention has been strongly directed to the powder question in England. In Russia and Prussia where great efforts have been made to obtain endurance with large rifled guns, powder similar in granulated form to that used in England has long been wholly discarded and superseded by powder stamped into prismatic blocks, which burn more slowly; but although we have erred in using a powder for our new ordnance, so violent as to be justly designated "brutal" by the French, yet we have this satisfaction, that the ordeal which our guns have sustained with our severer powder, affords an assurance of strength which we could not have had if they had only withstood the mild description of powder with which alone continental guns have been successfully tried. Attention is now fully awakened to the subject, and a scientific military committee is conducting experiments upon the force of different descriptions of powder. In these experiments the pressures exerted in every part of the gun are determined, by the use of an instrument of equisite delicacy, invented by my friend and partner, Capt. Noble. This instrument, which is a happy combination of mechanical and electrical action, indicates the velocity attained by the projectile at any number of points in the gun, and from these velocities the pressures are deduced by calculation. Thus a diagram of pressure can now be exhibited for gas in a gun, as well as for steam in a cylinder, and I think you will agree with me in regarding this result as no small triumph of mechanical science. The mitigation of initial pressure, which is now known to be compatible with the maintenance of efficiency, opens a new future for guns, and removes all doubt as to the practicability of increasing their size and power to an extent which it would be vain to follow on the side of the defence by increase in the thickness of armour. No present armour-clad vessel is proof against present guns, and there is not the slightest probability that future armour will be proof against future guns. Ships of the *Warrior* class can already be pierced with shot or shell, fired at considerable ranges, by even second-class guns, and the still stronger ships, now in course of construction, are pretty sure to be similarly overtaken in a very few years. Unless armour be invulnerable, it is of very doubtful advantage as a defence. It will, perhaps, prevent the entrance of shells, containing large bursting charges but on the other hand the passage of a shot through the thick side of an armour-clad carries with it a mass of fragments that would act with terrible effect upon the crew. If we cannot stop a shot, the next best thing is to facilitate its passage through. Wooden ships are out of the question, because they are combustible, but we may have ships of iron without the armour. Whatever weight we carry as armour, we lose as armament, and if we lessen the offensive power of a ship, by loading her with armour, we ought to be very sure that the armour will realise its defensive purpose. The efficiency of modern ordnance against armour-plates is dependent, not only on the power of the gun, but also upon the material and form of the projectile. Ordinary cast iron proved absolutely useless for projectiles to be used against thick armour-plates, and until Major Palliser applied the process of chilling to the manufacture of cast-iron projectiles there was every reason to believe that hardened steel was the only material that could be used for this purpose with effect. The process of chilling gives extreme hardness to cast iron, but, in point of toughness, a chilled cast-iron shot is inferior to one of steel. Steel, however, though much less liable to break, is more easily crushed; and this brings me to notice a curious evidence of difference in the amount of the penetrative power lost by crushing and by breaking. A crushed projectile is always much heated by the blow, but the fragments of a chilled projectile remain cool. Hence we see that crushing detracts more from the power of a projectile than breaking, because the heat developed in a projectile by striking a plate, is a criterion of the amount of force expended upon the projectile instead of the plate. We accordingly find that a Palliser shot breaking by impact will nevertheless pierce more easily than a steel shot which remains whole, but yields to crushing. As to the proper form of head to be given to the projectile for piercing armour, you will remember that a few years ago this question was hotly contested between the supporters of round heads and flat heads; but, as often happens in the case of human contentions, not limited to the sphere of mechanical engineering, both parties were afterwards proved to be wrong. When Major Palliser brought forward his chilled projectile, he advocated a pointed head, and with the new material he was found to be right. Major Palliser has competitors on the Continent, whose claims I cannot pretend to weigh, but in this country, at all events, he is entitled to the honour of improving both the material and the form of the projectile, thereby greatly increasing the penetrative power of our artillery, and, at the same time, effecting an enormous economy in the manufacture of projectiles. The most legitimate use of instruments of war is for the purpose of home defence, and I, therefore, proceed with satisfaction to notice a class of inexpensive vessels requiring no armour, and adapted to render the heaviest artillery available for the protection of our shores and harbours. Until very recently, there seems to have been an impression that large guns required large vessels to carry them: but the fallacy of this idea has been practically shown by the proving barge of the Elswick Works, which is a mere floating gun-carriage. This little vessel, which is only sixty tons burden, is continually used, without difficulty, for the trial of twelve-ton guns at sea, even when the swell is considerable. This proving barge was the origin of Mr. Rendell's idea of the now well-known gun-boat *Staunch*. The *Elswick* barge has no steam power, and thus represents the minimum of size; but the *Staunch* is provided with steam power, both for propulsion by means of twin screws, and for working her twelve-ton gun. She is, therefore, somewhat larger than the *Elswick* barge, and yet so small as to be very inexpensive, and at the same time a very difficult mark to hit. To burden such a vessel with armour would at once increase her size and her cost, thus rendering her more easy to hit, and more expensive to lose. A simple screen might, perhaps, be advantageously applied as a protection against shrapnel; but thick armour if used at all, should be reserved for ocean ships. I have so recently published my views on the subject of this vessel that I need not now repeat them further, merely observing that guns of the largest size now made, or ever likely to be made, may be mounted in vessels similar to the *Staunch*, without increasing their tonnage in more than a proportionate degree. Another recent invention, highly favourable to defence, is the celebrated gun-carriage of Captain Moncrieff. By the ingenious arrangement of this carriage, the recoil of the gun operates in a downward direction, and in descending it lifts a counterweight, which when liberated, after loading, raises the gun again to the height necessary for firing over the edge of a parapet. By this mechanism, the gun is handled with almost perfect security to the men, and is itself exposed in the smallest possible degree, and only for a few seconds while being fired. No embrasures being required, the gun is not restricted in lateral range. This is the characteristic advantage of the barbette system of mounting guns, which has, however, the fatal objection of exposing both guns and gunners. Embrasures are always a source of trouble in fortifications. They not only admit but guide projectiles into the fort at the very points where guns are placed. In iron defences, the opening for the gun is even more objectionable. Not only does it weaken the whole structure, but it serves to break up cast-iron shot, striking on the edge, and thus to occasion terrible destruction inside. I may state as a fact, communicated to me by a Brazilian officer, on whose testimony I rely implicitly, that in the late Paraguayan war, in which he was engaged, he saw whole gun crews swept away in the Brazilian iron-clads by common cast-iron round shot, contemptible for piercing even the weakest armour, but which, striking the edge of the port, entered the ship in a torrent of fragments. The Moncrieff gun-carriage gives great additional value to earth-works, and, in fact, may by used in mere pits which would be wholly invisible to an enemy. It will probably also prove to be availble in combination with iron defences as a means of avoiding the objection of port-holes, and it will have the effect of placing muzzle-loading guns on a par with breech-loaders in regard to security and ease of loading. Captain Moncrieff's invention will play a very important part in defensive operations, and will greatly reduce the expense of fortification. Many other instances may be cited in illustration of the tendency of mechanical progress to favour defence. Thus the increasing size of guns renders them difficult to transport for offensive use abroad, but creates no impediment to their defensive application at home. Or, if we look to the nautical side of the subject, we see that the conditions sought to be attained in war-ships for aggressive action involve enormous cost, and that the great size of these vessels makes them favourable targets for the fire of opposing artillery. On the other hand, the vessels required for coast and harbour defence are of cheap construction, and their small size and facility of movement give them the advantage of being difficult to hit. The Moncrieff carriage is applicable almost exclusively to defensive purposes; and the same may be said of torpedoes, which by many ingenious contrivances, have recently been rendered most formidable obstacles to naval attacks upon seaports. The tendency, therefore, of mechanical invention, as applied to war, is to discourage aggression. and thus to maintain peace, We may, consequently, hope that it will hasten the arrival of a period when civilized nations will abandon the arbitrament of arms, and settle their differences by rational and peaceable methods. But, while I defend the mechanical branch of military science from all imputation of serving the cause of war, I do not forget that it is to the civil branch of mechanical engineering that the honour of promoting the friendship of nations especially belongs. It is by the facilities it gives to intercourse and exchange, and by the reciprocal benefits which flow therefrom, that it teaches men how much they have to gain by peace and lose by war.

## HYDRAULIC MACHINERY FOR WAREHOUSING GRAIN.

A paper by Mr. Percy G. B. Westmacott, of Elswick; was read by the Secretary, the subject being a description of the hydraulic machinery for warehousing grain at the Liverpool Docks. The following is an epitome. Blocks of warehouses have been erected by the Mersey Dock and Harbour Board, ably designed and executed under the supervision of Mr. Lyster, the dock engineer, for the stowing and conditioning of grain and bread stuffs. The dock upon which they are situated is 570ft. wide by 230ft. broad at one end, and 180ft. at the other, with a depth at high water spring tides of 34ft. over the sill of the gate. The blocks on the east and west sides of the dock are 650ft. long; and that on the north end 185ft., the whole range being 70ft. wide. The buildings contain five storeys. Above the fifth or upper storage floor and partly in the roof is placed the machinery floor, and below the quay level are wells and arched subways for the reception of the underground machinery. The total storage capacity of the floors exclusive of the quay floor (at 4qrs. to the square yard) amounts to 196,000qrs. of grain. The ends of the east and west blocks are constructed to receive iron chambers for conditioning grain on the Deveranx system in order to prepare it for the market by drying. The steam engine, the prime mover of the whole plant of machinery, was of 370 horse power, and that in addition to driving the machinery in the warehouse, supplied power working for the lock machinery and the bridge over the entrance, consisting of two 60ft. and one 50ft. bridges, twelve sluices, ten powerful ship capstans, and twenty-four machines for opening and closing the lock gates. From returns taken of the importation into Liverpool of the different descriptions of breadstuffs for the years 1858-63 it was estimated that the warehouses should be constructed capable of working 250,000 tons per annum, irrespective of other ordinary merchandise. Having described the principal processes required to be performed by the machinery, and the best means likely to secure the requisite power, and especially the kind of power, and the most convenient, practical, and least costly method of applying and distributing that power, the writer stated that it was found after experiment that no system of motive power or combination of systems could be found to meet those requirements in the aggregate with so much effect, convenience, and economy as the hydraulic system. Having noticed the facility with which this power had been conveyed for long distances at the Birkenhead docks, and also the advantages otherwise of propelling grain horizontally by means of screws, the author stated the results of the latter system. At 60 revolutions per minute (the maximum effective speed) grain could be discharged by a screw in use at a certain brewery, at the rate of 6¾ tons per hour, being at the rate of 1-25th horse power for every foot run. With a screw subsequently put into operation of 12in. diameter, and driven at the rate of 70 revolutions per minute (the most effective speed), 34 tons of grain per hour were discharged. The effect upon the grain in the latter case was marked, it being rubbed and polished, and thereby improved in marketable condition. But the long distance through which the grain had to be conveyed horizontally, amounting collectively to 7,000ft., and the power required to perform the operation, even with the best form of screw, rendered it expedient to seek some other method less absorbent of power, and recourse was had to endless travelling bands. Experiments were made with a 12-in. band, constructed of canvas and india-rubber. It was found that a speed of 9ft. per second could be attained with heavy grain, and still more with peas. The amount of grain discharged by the 12-in. band at the speed of 8ft. per second, was at the rate of about 35 tons per hour. Further trials were carried on with an 18-in. band, made of two plies of stout canvas, covered with vulcanised india-rubber. To meet the requirements of passing grain from off the straight bands to either side at certain points along the travel, several contrivances with air blast, and brushes driven from the band itself, were tried, but with indifferent success. Both methods were objectionable on account of raising dust, and the friction of the brush proved in time injurious to the band. The idea then occurred of diverting the line of the current of grain by means of an upward deflexion of the band, thus casting the grain clear from the band into the air for a short distance; it could then be received upon a band travelling in any other direction, and if necessary, could be passed round the warehouse from one side to the other, or even make a circuit of three sides of the block, according to the method in which it was intended to dispose of it, or the place in which it was to be deposited. The were fifty-six spouts, 8¼in. square, from the upper to the various other floors. No difficulty was experienced in keeping the grain on the band, but it was found necessary to glide the grain on to it from the feeding hopper, through a spout rather less than half the breadth of the band, at an inclination of 42½ degrees, which would impart a velocity to it on falling approximating to that of the band. The maximum amount of heavy grain conveyed by the 18-in. band was at the rate of 70 tons per hour; the power required for driving the band when fully loaded was ascertained to be equal to about 1-70th horse-power effective per foot run. The paper then described the boiler and engine, &c., and also other apparatus with which the warehouses are furnished, including the cranes and the two accumulators, each of which latter is weighted with a load of 70 tons, acting on a ram 17in. diameter, and the auxiliary accumulator with a load of 100 tons, acting on a 20-in. ram. The form of tub in which grain is lifted from the holds of ships, and the hoppers through which it is passed for various purposes, having been minutely described, the author detailed the construction and capacity of the elevator, which consists of a wrought-iron bucket, capable of containing about 21 cwt. of grain. It was slung in an arrangement of bars and levers, provided with guiding rollers, which enabled the bucket to run in special grooves to the top, for the discharge of the grain into the upper hopper, which communicates with the same cross bands that convey the grain from the hopper under the crane. Casks, bags, and other merchandise might be raised or lowered by two classes of machines—one by means of the hydraulic cradle hoists, of which there were 12; the other by means of 20 jiggers. Twelve double-acting 10 cwt. jiggers had also been added to the plant in the central block, to lift and lower goods to and from railway waggons. The paper lastly directed attention to one of the great advantages which the hydraulic system possessed in so eminent a degree, namely, the facility afforded for the extension of power to any point where the demand for additional contrivances to save time and band labour was felt.

Mr. Westmacott, in reply to a member, said that the apparatus had been in operation upwards of a year. There had been no tendency, as yet observed, in the bands to wear out, though they had done an immense amount of work. The grain sustained no injury from the bands, as when propelled by the screws.

## THE NAVIGATION OF CANALS.

A very voluminous paper, prepared by Mr. Max Eyth, of Leeds, was afterwards submitted "On towing boats on canals and rivers by a fixed wire rope and clip drum." The subject was profusely illustrated by coloured diagrams of very great size; we append the following abstract:—

In the application of steam power to river and canal navigation, the writer remarked, the greatest obstacle to be encountered had been the loss of power that was inseparable from the ordinary methods of propulsion by paddle-wheels or screw propellers. As the resisting water formed the fulcrum upon which the bearing was taken for propelling the vessel, the result was that a great quantity of water was put in motion, and a considerable amount of power exercised without any useful effect being produced. Thus, even under the most favourable circumstances, when working on a broad sheet of deep water, the ordinary propellers lost from 40 to 50 per cent. of the power applied to them: and, under the peculiar circumstances met with on rivers and canals, their useful effect was frequently reduced to less than 25 per. cent. of the power applied. On canals, the increased difficulty to be encountered arose from the presence of the locks, the small section of water through which the boats had to be driven, and the swell produced by the increased speed of the boats, for which the small section of water was not originally calculated. Moreover, as the only admissible means of propulsion was by screws or paddle-wheels placed at the stern, the water put in motion by them was withdrawn from the stern of the tug, and thrown against the bows of the boats in tow; the water level in the canal was thereby disturbed, and the hollow created at the stern of the tug had to be filled up by the water in front of the tug running backwards through the narrow passage left between the tug and the sides of the canal. The consequence of this was that engines of considerable power had to be used for towing a given freight; and hence, owing to the small size of the locks through which they had to pass, it was of the utmost importance that the engines employed should occupy as little as possible in the holds of the vessels, in order that the cost of steam propulsion might not be further increased by a source of diminution in the amount of freight that could be carried. As it was admitted that a dead pull from a fixed point was undoubtedly the most effective mode of gaining power, it had now been determined to adopt a system on canals and rivers of towing by means of a fixed wire rope and clip drum. The rope was laid in the bed of the river or canal from end to end, being anchored only at its two extremities, and an engine on the deck of the boat was then attached to the rope and wound itself along to its destination. The idea was not altogether new, as attempts had been made on the Rhine by the French Marshal de Saxe, as early as the year 1732, to transport war material through different rivers of the country by means of a horse windlass on the boats, which wound up a rope made fast on the bank of the river at the extreme end. In 1820 a regular service on the same principle was established on the Rhone, by Tourasse, and it successfully overcame the difficult portions of the river between Givers and Lyons. After noticing the drawbacks of the plan, however, and the many obstacles in the way of a free use of chains or winding drums, the paper added that the present system—consisting of a clip drum working along a submerged wire rope—had been invented and matured by Baron Oscar de Mesnil, a Belgian gentleman, and the author himself; the first experiment having been made at Leeds in 1866 for John Fowler and Co., and since repeated more extensively on several American canals and also in Belgium. The first application of the submerged wire was made on the river Meuse, where a line 42 miles in length—from Namur to Liege—had been in successful operation since 1868, and was now being extended 90 miles through the Canal de la Campine to Antwerp. Having described the Canal de la Charleroi, in Belgium, the writer added that one of the boats on it was 62ft. long by 8ft. broad, and drew 3ft. water; while the wire rope, five-eighths of an inch in diameter, wound round a 5ft. clip drum. In addition to these there was a winding drum used for the purpose of obtaining a sufficient amount of slack in the rope for enabling the tug, when off the rope, to hitch on again at any place without delay. The speed of the engines here, 10-horse, was 80 revolutions per minute with 90lbs. pressure of steam, and the speed varied from one to three miles; but on the river Meuse they had engines of 14-h.p., working up stream at from three to six miles an hour, although on the downward journeys this could be increased to ten miles by running the engine at 120 to 130 revolutions. In some places, also, they had smaller boats fitted with portable engines—engines that could easily be transferred from one boat to another; and while these were, by a very ingenious contrivance, enabled to pass through the narrowest parts of a canal or the lowest bridges, they could easily travel at 2½ miles an hour with two 200-ton barges fastened behind them. The ropes were in all the cases laid along the side of the deck, and never being long exposed to the air they were not liable to injury by oxidation, neither were they subject to fracture or obstruction on the bed of the river. The rope used on the river Meuse was only one inch in diameter of iron wire, the greater part being galvanised, and having a breaking strain of 14 tons. The weight was 4¾lbs. per yard, and cost, including the laying down, £93. The maximum work done by one tug of 14h.p., was towing 18 boats containing a total cargo of 1,000 tons; while, by another, 1,500 tons freight was towed in 10 boats. Both trips were made up stream, and at from 2½ to 3 miles an hour, including stoppages. The average work of the tugs was to tow 700 or 900 tons of cargo, in 8 or 12 boats of different sizes—the steering in all cases being good—while the average amount of coal consumed by the 14-horse tug amounted to three-quarters of a hundredweight per mile, and the working expenses to £22 per month. The cost of towing on the canals where the system was now in operation, amounted to not more than 0·05d. (or one-twentieth of a penny) per ton per mile, including the working expenses, the management, the interest, and the redemption of capital. This result was not only another illustration of the great advantage which inland navigation possessed over any other mode of carrying heavy traffic where speed was not required, but it also proved the important commercial value of this particular mode of towing as compared with any of the other methods hitherto in general use. The average cost of towage by animal power on four English canals amounted to 0·35d. per ton per mile, and on seven French canals was 0·27d. With paddle tugs on the Thames the cost was 0·48d., and on six rivers in France it was as high as 0·80d. per mile. The employment of screw tugs on three English canals resulted in an average cost of 0·27d.; whilst towing by boats carrying their own machinery cost, on seven English canals, 0·20d. per mile. In conclusion, the author remarked that while railways had undergone so wonderful a development during the past thirty years, the quieter, but often more important, mode of transporting heavy goods by inland navigation had remained comparatively neglected. It was true that the natural features of England were not very favourable for inland navigation, although there was in the United Kingdom a total length of 2,000 miles of navigable water courses; but on the continent, in the colonies, and especially in India, there was a vast amount of traffic for which no better highways could be found than those already traced by nature in the rivers and streams penetrating the interior of the country. The system of wire-rope towing that had now been described, placed inland navigation in a similar relative position to that in which the road traffic was placed by the introduction of the railway and the locomotive. By means of the clip drum, the tug obtained a hold upon the flexible rope laid on the water course precisely in the same manner as the driving wheel of the locomotive took hold of the rigid rail upon which it ran; and the great advantage of steam power might, therefore, be similarly brought to bear on the movements of vessels in water—leaving to railways all their superiority in regard to speed, but restoring to rivers and canals their advantages in reduction of traction.

## REVOLVING BALL FURNACES.

The Secretary read a paper by Mr. R. Calvert Clapham and Mr. Henry C. Allhusen—"Description of a revolving furnace for chemical works." The writers stated that the conversion of sulphate of soda into crude or ball soda is the third process conducted in alkali works; and its importance will be understood from the statement that in the Tyne district alone 455,000 tons and L. 560,000 represent the total annual quantity and value of the sulphate of soda, chalk, and coals operated upon in reverberatory and revolving ball furnaces. The revolving furnaces were introduced in 1853 by Messrs. George Elliott and Wm. Russell, with the object of effecting by machinery that which from 1794 had been accomplished by hand labour; but, owing to the numerous practical difficulties encountered, the economy and other advantages expected, were not realized, and no extensive application of the cylindrical furnace would yet have taken place had it not been for the perseverance of Messrs. Stevenson and Williamson, of the Jarrow Chemical Works, who made sundry improvements on the original plan, and erected five of the fifteen revolving furnaces now working in England. In this description of furnace the charge of material to be acted upon is placed in a revolving cylinder, constructed of 5-16ths boiler plate, lined with fire bricks, and mounted so as to allow the heat from the furnace at one end of the cylinder conveniently to pass through it, and over the liquid contained in the evaporating pan at the other end. In the brick lining are fixed two rows of fire-clay blocks, termed "breakers," by which the contents are thoroughly mixed and successively exposed to the air. Between the furnace and cylinder a loose collar is adjusted consisting of a wrought iron hoop lined with brick work; and between the pan and cylinder at the other end is left a space, termed the smoke chamber, so that the greater part of the materials carried forward by the strong draught may be deposited there instead of in the liquid to be evaporated. In the downcast at the extremity of the pan, a main or horizontal damper is chained, so that no more than the requisite draught can be taken—further control being given by a vertical damper placed between the pan and down-cast, and counterbalanced by a weight suspended near the engine. The "charge" at Messrs. Allhusen's works consists of sulphate of soda 22 cwt.; chalk, 25 cwt.; coals, 12 cwt. The sulphate of soda falls through a ¼-in. screen. The chalk is charged in as delivered into its depot, whilst the coals are divided, 3cwt. being mixed with the sulphate, and 9cwt. with the chalk.

On the day shift, five charges are worked; on the night shift, six; the full work being six days, at 12 tons 2 cwt., sulphate of soda 24 hours. The method of proceeding is as follows:—The 25 cwts. chalk, and 9 cwts. coal are charged, and the cylinder is made to revolve in the slow motion. After 1 hour 10min., the conversion of the chalk into lime, or "liming," is generally effected, and always indicated by a bluish flame round the charging door; the 22 cwt. sulphate and 3 cwt. coal are then added, the vertical damper being lowered for ten minutes so as to give the smallest amount of draught. In about twenty minutes after the vertical damper has been raised, the fluxing of the sulphate becomes apparent by the escape of a bright yellow flame round the charging door, and the workman at once changes the motion from slow to quick. A small door in the arch over the pan enables him to ascertain when the decomposition of the materials is sufficiently advanced, which he judges by their clear colour and increasing consistency, and also by the light yellow jets of flame from portions of the fluxed mass adhering to the breakers. This stage is usually attained in half an hour, when the contents are run out, the total time expended on each operation being on the average two hours and ten minutes. The writers compared the revolving with the ordinary furnace. The rate paid for charging the furnaces was identical: but in working there is a distinct saving in wages of a shilling per ton of sulphate—2s. 6d. for hand and 1s. 6d. for revolving, heating included. The chemical results are slightly in favour of the cylinder, so far as the quantity and strength of the alkali produced are concerned, especially where causticity is required; but in works where chalk is used, the carbonate of lime carried over by the draught into the evaporating pan is found to render the salt drawn not so well adapted to the manufacture of crystals of soda as that taken from the hand-furnace drainer, although in the majority of alkali works, where the revolving furnace has been adopted, the opinion obtains that, in addition to general superiority over the reverberating furnace, it also presents an evident advantage during wages disputes, yet there are sufficient grounds for stating that obstacles still exist which must be modified, if not removed, before the old furnace can be entirely superseded by the new. In the latter, improvements are clearly demanded, by which the consumption of fuel and the cost of repairs may be reduced, whilst the quantity of sulphate balled, and quality of carbonate produced, may be raised; and if the difficulties hitherto experienced have been prominently brought forward in these remarks, it is in the hope that, by the attention directed, they may more speedily be overcome.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON THE INFLUENCE OF CIVILISATION UPON HEALTH.

By John H. Bridges, M.A. M.B.

Rousseau, representing the metaphysical and absolute spirit of the revolutionary politicians of the eighteenth century, maintained that civilization was destructive to health and morals, and would have it altogether swept away. The positive sociologist recognising that the phenomena with which he deals, like all others, are amenable to natural laws, seeks to find out what the law—the natural tendency of modern civilisation—is, and how it may be modified by human effort in a direction favourable to the moral and physical development of the individual. It is the greatest of all problems. Leibnitz's maxim, *On ne doit penser essentiellement qu'à deux choses, d'abord la vertu et puis la santé*, may be taken as the text of this discourse.

Health may be defined as, the greatest energy of each part compatible with the energy of the whole; or again, more simply, as being able to do good day's work easily. Energy is measurable by the amount of work done. Where there is perfect health there will be the greatest economy of the vital energies; the most complete synergy of the functions, the minimum of loss from antagonism or from degradation of higher into lower forms of force. Three examples were taken taken by the speaker; good and bad digestion; clumsy and skilful muscular effort; uncontrolled and self-contained emotion, as shown in the contrast between the well-drilled soldier and the savage. In the imperfect performance of each of these three functions there is waste of energy; that is, ineffective transformation of nervo-muscular into calorific or some other lower form of force.

Again, health may be defined as the most perfect form of life. Life having been defined by Auguste Comte, as the constant adaptation of organism to environment, health is the state in which such adaptation is most complete. Healthly respiration implies the adaptation of a breathing apparatus hereditarily vigorous to a perfectly pure atmosphere. Healthy vision implies a sound ocular mechanism adjusted to appropriate conditions of luminous forces.

Rising from the vegetal and the animal phase of life to the highest mode peculiar to man, the social phase, we find that social life depends, like the others, on two conditions: a brain in which lies latent the hereditary capacity for receiving and transmitting the long tradition of our race, its emotions, its thoughts, its modes of action; and a social environment supplying the appropriate stimulus which calls these latent capacities into action. The environment for this phase of vitality is humanity; that is to say, the resultant sum of all human effort throughout the immeasurable past, represented more or less perfectly by the society in which the lot of the individual may be cast. The function of the human brain, as transmitting the mutual reactions of humanity and the individual, has been compared by Comte to the function of the placenta with the mother and the unborn child.

The speaker then proceeded to point out the influence upon the individual of different social environments. In order to render the meaning more precise a single well-defined instinct was chosen, the desire of praise. In one society personal bravery might be the object of the highest admiration; in another it might be civic duty; in others, religous asceticism. Obviously the instinct under consideration would in these three societies prompt three wholly distinct courses of action; and in a society like our own, which had ceased to be warlike, which was too overgrown to encourage the sense of citizenship, and which from a combination of courses had lost its religious faith, wealth, as comprising the power of individual enjoyment, became the object of the highest admiration. The instinct of "approbativeness" therefore would in such a society prompt the acquisition of wealth. The same analysis would hold good of the action of the other instincts. In a society without strong religious faith, without any firm binding principles, and endowed with new and extraordinary powers over natural forces, the inevitable result is immensely rapid accumulation, accompanied by prodigal expenditure, of wealth; with small regard to health, with small provision for the future maintenance of the vigour of the breed.

The speaker then proceeded to consider some of the principal facts illustrating the morbid condition of modern industrial life:—

1. The growth of great towns in the last half century.
2. The influx into these towns from country districts.
3. The mortality of infants.
4. The mortality of adults at the reproductive age.
5. The condition of the agricultural population, which may be regarded as the reserve stock of national vitality on which rapidly increasing demands are being made.

With regard to the two first heads, statistics were produced showing that in 1811 the towns above 10,000 inhabitants contained only 24 per cent. of the population; in 1861 they contained 44 per cent. In 1811 there was no town in England, except London, with a population above 100,000; in 1861 there were twelve such towns, containing one-quarter of the people. To illustrate the extent to which the increasing population of London was fed by the rural districts, it was mentioned that out of eleven persons over the age of twenty in London, six were born in the country.

Statistics and charts were then produced, illustrating infant and adult mortality. Four populations were compared: that of England as a whole; of Liverpool; of ten cotton manufacturing towns of Lancashire and Cheshire, not including Manchester; and of seven purely agricultural countries. These populations were compared: first, with respect to their rate of mortality at the infantile period; secondly, at the reproductive period; the mortality in the case of women being examined at successive periods from 15 to 45; in the case of men, from 25 to 55. It was shown that in both periods the rate of mortality in Liverpool and the cotton districts was far above the rate for England at corresponding times; that of the agricultural districts far below it. Attention was also called to the fact, that in towns where women were largely employed in factories, their mortality relatively to men of the same age was far beyond what it should be, taking the standard of England as a whole.

The question was started whether the excessive mortality of infants might or might not be regarded as a preservative action of nature, sacrificing the unhealthy lives, and so preserving the vigour of the breed. It was also considered, whether or not sanitary measures, by preserving weak lives, might not in some measure tend to deteriorate the breed. With regard to the latter point, the speaker's view was that unless sanitary measures were carried much farther and deeper than the present, there might be some such danger. And meantime he brought statistics to show that the high rate of mortality in infants in large towns did not preserve the reproductive portion of their population from similarly high rates.

After a brief allusion to the unsatisfactory condition of our reserve stock of health, the agricultural population, the speaker then proceeded to discuss the historical causes of this state of things. He showed, by illustrations from the vegetable and animal kingdoms, that the state of equilibrium we call health is more difficult, yet at the same time more perfect, as we ascend from the lower organisms to the higher. The same holds true of primitive and barbarous times as compared with the more advanced stages of civilisation. Reference was made to Capt. Cook and to travellers in Central Africa to prove the remarkable immunity from European disease enjoyed by savages. The influence of an organised religion in controlling social action, and its bearings upon public health, were then considered, and were illustrated by allusion to the theocracies of Egypt, Palestine, and India, to the military polytheism of Greece and Rome, and to mediæval Catholicism. The two causes of the decline of Catholicism, the decay of theology, and the growth of science, were then pointed out, and it was shown how both these causes co-operated in producing the exceptionally morbid state of modern industrial England.

The question then remained, by what methods can we hope to remedy this state of things?

There are two forces, the speaker remarked, available for the modification of natural social agencies—capital, and scientifically trained intellect. If asked, therefore, where lies the efficient and radical remedy for the evils we deplore, the answer would be, nowhere but in a moral and religious change as profound as that of the first century of our own era in western Europe, or that of the seventh century in the East, the principal result of which will be to concentrate these two forces on such problems as have here been discussed. The present attitude of scientific men does not inspire immediate hope in this respect. Absorbed in their own specialities, they revolt against the idea of any moral or spiritual discipline, which would have the effect of concentrating their investigations more closely round human interests, although these, largely viewed, offer an abundant and super-abundant field for every intellectual energy. They rebel against all such claims as unpleasant restraint. And the sense of civic duty is restraint. *Noblesse oblige.*

This great remedy therefore will be slow in its action. But while there are some remedies which are deep, but not immediate, there are others which are immediate, though not deep. To some of these the speaker briefly alluded. A revision and consolidation of our sanitary laws; the appointment by Government of public inspectors of health; the introduction of very simple sanitary teaching into our primary education; the establishment on a large scale of public parks and gymnasia; and finally, special attention to the sanitary and social requirements of the agricultural labourer, from whom it was essential not to cut off, as had been done during the last century, the hope, however distant, of becoming a peasant proprietor.

With regard to the cost of these and similar measures, the speaker merely remarked that London alone expended a yearly sum of between three and four millions upon doubtful charities; and that we had found little difficulty in raising ten millions, of late years, to protect ourselves against the imaginary danger of invasion. Whereas the dangers now pointed out were not imaginary, and were undoubtedly progressive.

## MANCHESTER STEAM USERS' ASSOCIATION.

### CHIEF ENGINEERS' MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, June 29th, William Fairbairn, Esq., C.E., F.R.S., LL.D., &c., president. in the chair, the previous meeting having been held on Tuesday, June 1st, Charles Heaton, Esq., Bolton, in the chair. On both occasions Mr. L. E. Fletcher, C.E., presented his usual report, but on account of the amount business before the committee on the first occasion the meeting was adjourned, and therefore an abstract is now given of his report for the past two months.

"During the past two months 446 visits of inspection have been made, and 934 boilers examined, 558 externally, 11 internally, 4 in the flues, and 361 entirely, while in addition 6 have been tested by hydraulic pressure. In these boilers 438 defects have been discovered, 13 of them being dangerous. Furnaces out of shape, 14; fractures, 73,—1 dangerous; blistered plates, 31,—1 dangerous; internal corrosion, 53; external ditto, 66,—5 dangerous; internal grooving, 60,—2 dangerous; external ditto, 2; feed apparatus out of order, 1; water gauges ditto, 6; blow-out apparatus ditto, 9,—1 dangerous; fusible plugs ditto, 2; safety-valves ditto, 4,—2 dangerous; pressure gauges, 36; boilers without glass water gauges, 15; ditto safety-valves, 1—dangerous; ditto pressure gauges, 14; ditto blow-out apparatus, 19; ditto feed back pressure valves, 32.

### "Overheating of Furnace Crowns and other Boiler Plates when covered with Water.

"Everyone at all conversant with the working of boilers is aware that when they are allowed to run short of water the furnace crowns are apt to become overheated, the plates to be bulged downwards or otherwise distorted by the pressure of the steam, and in many cases to be rent, from which cause explosions frequently arise. This is admitted on all hands, and the rationale is so simple that the whole must be at once apparent.

"It is not however by any means so generally known that furnace crowns may be overheated and bulged out of shape—sufficiently to in some cases to cause an explosion—even when they are covered with an ample supply of water. Such, however is unquestionably the fact, and I wish specially to call attention to this subject on the present occasion.

"Overheating of boiler plates when covered with water has been found to arise from two causes, one, the local action of an intense fire, the other the character of the feed water.

"Injury from intense firing sometimes occurs to boilers heated by the flames passing off from separate furnaces constructed of firebrick, as in the case of puddling furnaces at iron works, when the flames are too frequently allowed to impinge directly upon the boiler, in consequence of which steam is generated so rapidly that the water is driven off from the plates, and overheating ensues. This is more especially the case where the heating surface is a vertical one, so that the steam on rising forms a separating film between it and the water. Two explosions resulting from this cause may be referred to. One of these occurred at an iron works on the 9th of February, 1865, to an externally-fired boiler, of the upright furnace class, heated by the flames passing off from two puddling furnaces, as well as from a large firegrate. Another explosion of a similar character occurred on the 7th of February, 1866, to a plain cylindrical egg-ended boiler, heated by the flames passing off from a mill furnace at a works employed in the manufacture of angle iron.

"It is desired, however, on the present occasion to call attention more especially to those cases in which overheating of the plates, whether in externally or internally-fired boilers, has occurred simply through the character of the feed water, and not from any peculiarity in the mode of firing. The feed water which is found to be more particularly productive of overheating, is highly impregnated with carbonate of lime. It forms but little scale, and seldom thicker than an egg shell, though perhaps in some cases it may be nearly equal to one eighth of an inch. It deposits, however, a good deal of fine flour or dust, which is generally of a lightish colour. As this dust is quite loose, a good deal of it is floated away with the water when the boiler is emptied, while the remainder is readily washed out, so that on account of the ease with which it is removed and the light character of the scale, it frequently escapes attention. If grease be introduced into boilers in which this deposit is formed, the furnace crowns are found to give way, the plates to bulge downwards, and leakage to take place at the seams of rivets. The distortion of the furnace plates, however, does not, as a rule, take place suddenly, on the contrary, the crowns come down gradually, progressing little by little day after day, though hard firing in many cases has an immediate influence. Grease is introduced into boilers in various ways. The feed water is frequently heated by blowing the exhaust steam from the engines upon it, so that the grease in the cylinders is carried with the feed water into the boiler, while in addition, the discharge taps from the cylinders sometimes blow into the cistern from which the feed pump draws, so that the boiler gets all the engine sewage. Blowing the exhaust steam upon the feed water has another effect beside the introduction of grease. It is sometimes lost sight of how much of the deposit formed within boilers is lifted out of the water by the steam and carried through to the engines, and thus disposed of either through the exhaust pipe in the high-pressure engines or the hot well in low-pressure ones. When therefore the exhaust is blown upon the feed water this deposit is returned to the boilers, and a constant accumulation takes place, more especially if blowing-out be neglected. That the steam lifts the deposit, and carries it along with it is clear from the fact that it is frequently manifested at the glands and other parts of the engines, and also is heaped up in the steam dome when there is a shelf on which it can accumulate. These shelves are formed when the shell plate at the base of the dome is not cut away to its full size. This forms an eddy in the current of the steam, and leads to the deposit being dropped on the shelf plate as just stated.

"With regard to the manner in which this floury deposit affects the plates over the fire, and leads to their injury, it does not appear to be necessary to suppose that this deposit becomes heaped upon the plates in order to lead to their overheating. It is doubtful whether it settles at all as long as the boiler remains in active work; while, were it to do so, it would settle where the ebullition was the least violent, and thus not on the furnace crowns of internally-fired boilers. Possibly, this fine floury deposit, by thickening the water, interferes with the due escape of the globules of steam, so that they are kept longer in contact with the plates over the fire than they should be, and thus the intimate contact of the water with the plates becomes interrupted and overheating is produced. This may, perhaps, be illustrated in the following way:—Clear water placed in a clean saucepan may be briskly boiled over a fire without foaming over, but if a little meal be dropped into it, or the water exchanged for milk, the globules of steam are no longer able to escape freely, and in their struggle they upheave the whole mass, and vomit a portion of it into the fire.

"I am not desirous, however, of entering too minutely upon the precise manner in which this floury deposit leads to the overheating of the plates: suffice it to say, that the results are indisputable, that numbers of boilers have been injured by it, and whatever may be the precise *modus operandi*, it appears to have the power of preventing that intimate contact of the water with the plates, which is essential for carrying off the heat with sufficient rapidity, so that although they may not be made red hot, yet they become sufficiently overheated to lose a portion of their tenacity, when bulging under pressure ensues. Numerous instances of this have come before my notice, the particulars of some of which may now be given.

"No. 1. The first of the cases that may be referred to was met with about the close of 1862, and occurred to a boiler fed from a well sunk near the river Mersey, in the neighbourhood of Birkenhead. The boiler was of the ordinary Lancashire class, having two furnace tubes in which the fires were placed, while its length was about 20ft., its diameter 6ft. 6in. in the shell, 1ft. 10½in. in the furnace tubes, and the load upon the safety-valve 40lb. per square inch.

"This boiler had been found to give way again and again at the furnace crowns, the plates bulging down out of shape, and repeated repairs had taken place in consequence. The plates over the fires had been taken out and renewed with those of Low Moor iron, which had every appearance of being of first-rate quality. Also each of the furnace crowns had been lashed to the top of the shell by three vertical stay rods, but the plates persisted in bulging downwards notwithstanding, and came down between, and all round, the points of support as will be seen on consulting the accompanying cuts marked Figs. 1 and 2.

"Under these circumstance I was requested to examine the boiler and advise the owners as to what had better be done. Immediately on drawing off a little water from the glass water gauge I attributed the injury that had occurred to the furnace crowns to the fine deposit contained in the feed water, and recommended a scum trough for blowing out from the surface of the water, in order to rid the boiler of this deposit. In answer to inquiries the owners did not think they were admitting any grease to the boiler, and had such confidence in the feed water, which appeared so clear before it was pumped into the boiler that I was unable to persuade them to adopt the simple expedient of a surface blow-out apparatus. One cause after another was assigned for the injury, and it was supposed that as the boiler was worked night and day, that the water supply had been allowed to run short at night time, and that the deflection of the plates was due to a series of minor neglects of this character. On one occasion the owners felt sure they had at last detected the scource of the mischief. They discovered that the fireman, anxious to get away quickly on the Saturday evening, had started to blow off his boiler before he raked his fires, in consequence of which the furnace crowns were laid bare with the fires still in, and thus became overheated. In confirmation of this it was stated that it had been frequently observed on setting to work on Monday mornings that these deflections had been increased, so that the chain of evidence was supposed to be complete. It was soon found, however, that the bulging was too persistent to be accounted for in this way, and the owners, rather than adopt the simple expedient of putting in a scum trough for blowing out the deposit, which there is little doubt would have remedied the evil, resolved on condemning the boiler altogether and on putting in a new one.

"The new boiler was of larger dimensions than the old one, the diameter being 7ft. in the shell, instead of 6ft. 6in., and 2ft. 7½in. in the furnace tubes, instead of

1ft. 10½in., while the tubes were strengthened at the ring seams of rivets with encircling hoops, which had not been the case in the old boiler. With this new boiler, though not fitted with a surface blow-out apparatus, the same difficulty was not experienced as with the old one, which arose from the fact that the superior size of the new boiler enabled it to do its work more easily than the other, and thus with more gentle firing. As long, however, as the feed is of the same character as it was in the other boiler, the same tendency remains, and it will only be necessary to make the new boiler do as much work for its size as the old one did to lead to the furnace crowns being again disturbed, though doubtless they would derive considerable assistance from the encircling hoops, so that but little bulging of the plates might take place though leakage would occur at the seams of the rivets.

Fig. 1.

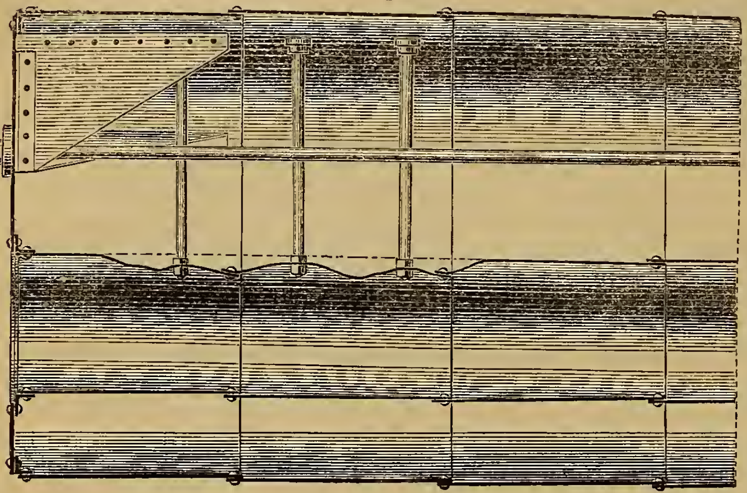
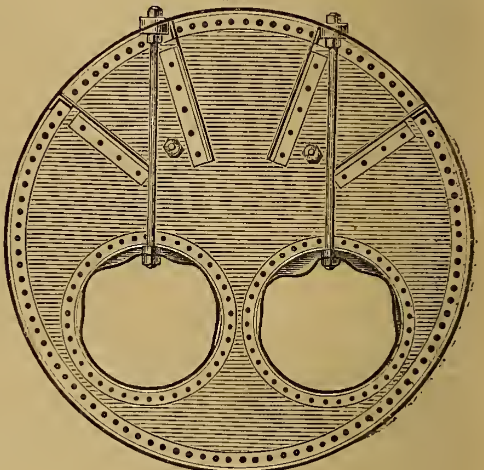


Fig. 2.



"In this case the water was not analysed, as it was on subsequent occasions, but it may be stated that it left a fine floury deposit of a very similar character to the cases mentioned below, and which were found to consist of from 70 to 80 per cent. of carbonate of lime.

"No. 2. Another very similar case of the failure of furnace crowns was met with in May, 1866. It occured in the neighbourhood of London to a Cornish boiler fed with the New River Company's water.

"This boiler I was informed had failed at the furnace crowns, and repeated repairs been resorted to. These, however, had such little effect, that one boiler after another had been laid down till some three or four boilers had been ruined in the course of three years; while one of the boilers had received a new flue tube. Added to this, experiments had been tried by altering the steam dome, and, altogether, the owner informed me the affair had cost him £700. Disheartened with these repeated failures, he was persuaded to exchange the internally-fired boiler for an externally-fired one with a couple of return tubes running through it, which he had just laid down at the time of my visit.

"On making an examination of the boiler I found that it contained a good deal of fine floury deposit of a light colour, and that the feed water was heated by the injection of the exhaust steam from the high pressure engines, so that the grease from them passed through into the boiler. I called the owners attention at once these facts, and explained to him that these were the causes of the trouble he had experienced. He urged by way of objection that prior to the last three years the boiler had worked for a considerable time with the same water and with the feed heated by the exhaust steam, without giving trouble, and therefore argued that the fault could not be with the water or the grease discharged by the engines. This objection appeared at first sight difficult to meet, but on inquiry it was found that about three years before then the work became too severe for the engine, when its power had been doubled by the addition of a new cylinder, which gave the boiler more work to do and necessitated its being more severely fired. This at once made the whole matter plain. The tendency had existed all along but had not been developed till the fires were pressed.

"The following is an analysis of the deposit in question:—

| | |
|---|---|
| "'Carbonate of lime | 73·87 |
| Carbonate of magnesia | 4·59 |
| Oxide of iron and alumina | 7·07 |
| Organic matter | 3·15 |
| Sand silica alumina | 11·32 |
| | 100·00 |

"'N.B.—This was a fine dry powder of a slate colour, difficult to wet with water.'

"It will not escape observation that this floury deposit contained as high an amount of carbonate of lime as 73 per cent., and, simple as it appears, it was through the presence of this fine flour or dust that the four boilers referred to above were ruined, and the expenditure of £700 incurred.

"In the new boiler a good surface blow-out apparatus was adopted, and the boiler was frequently blown out at the bottom as well as from the surface of the water. This proved sufficient to remove the difficulty, though the credit was wrongly given to the change from the internally-fired boiler to the externally-fired one. Externally-fired boilers are affected by this description of feed water as well as internally-fired ones, which will be seen from the next case of injury.

"No 3. A third case was met with in June, 1867, at a colliery in the neighbourhood of Ruabon, North Wales. In this instance six new plain cylindrical egg-ended externally-fired boilers failed within six weeks after they were set to work, giving way at the plates over the fire. These boilers were 5ft. 6in. in diameter, 36ft. long, made of plates three-eighths of an inch in thickness, and worked at a pressure of 40lb. per square inch. The owners threw the blame of the failure of these boilers on the makers, attributing it to the quality of the plates or workmanship, and consequently a dispute arose, and I was requested to make an examination. On doing this I found that the plates over the fire had of Low Moor iron and of good quality, and that the fault did not rest with the boilers but with the feed water, which formed, as in the previous instance, a fine floury deposit, consisting to a great extent, of carbonate of lime, while it was heated by the exhaust steam from the engines and thus charged with grease, in consequence of which, as in the previous cases, the plates over the fire had been overheated and bulged down out of shape, while, in addition, leakage had taken place at the seams of rivets. The manager was unwilling to accept so simple an explanation of the difficulty, though he had previously received a similar opinion from another engineer and been advised that he must either change the feed water or give up heating it with the exhaust steam, so as to prevent the introduction of grease to the boilers. Though ridiculing the recommendation, he had nevertheless diverted the exhaust steam from the feed water, when he found that the result justified the explanation given and the remedy proposed. Time showed that overheating did not recur, and the boilers worked on without further trouble.

"The following is an analysis of the deposit formed within these boilers, and which, I believe, was taken from them before the arrangement for heating the feed by the exhaust steam was given up, so that at that time grease was admitted:—

| | |
|---|---|
| "'Carbonate of lime | 75·26 |
| Sulphate of lime | 10·02 |
| Carbonate of magnesia | 8·78 |
| Oxide of iron and alumina | 0·47 |
| Insoluble matter (sand, &c.) | 2·68 |
| Organic matter | 2·79 |
| | 100·00 |

"'N.B.—This sediment was a white powder and smelt of tallow. By digestion with ether some grease was extracted and collected.'

"The following is another analysis of the deposit taken from these boilers subsequently to the last specimen, and after the practice of heating the feed water with the exhaust steam had been discontinued, when the boilers were fed with cold water:—

| | |
|---|---|
| "'Carbonate of lime | 84·10 |
| Sulphate of lime | 2·25 |
| Carbonate of magnesia | 8·73 |
| Oxide of iron and alumina | 1·41 |
| Insoluble matter (sand, &c.) | 1·98 |
| Organic matter | 1·53 |
| | 100·00 |

"'N.B.—The organic matter does not contain grease.'

"It will be observed the grease was detected when the feed water was heated by the exhaust steam, but not after that practice was discontinued.

"In addition to the above, further analyses were made at a later date both of the floury deposit and of the scale:—

| Floury Deposit. | | Scale. | |
|---|---|---|---|
| "'Carbonate of lime ......... | 80.00 | "'Carbonate of lime ......... | 77·40 |
| Sulphate of lime ............ | 6·08 | Sulphate of lime ......... | 9·52 |
| Carbonate of magnesia ... | 12·44 | Carbonate of magnesia ... | 10·90 |
| Oxide of iron and alumina | 0·98 | Oxide of iron and alumina | 1·22 |
| Sand, &c. ..................... | 0·5 | Sand, &c. ..................... | 0·96 |
| | 100·00 | | 100·00' |

"The following is an analysis of the water with which these boilers were fed:—

"'The total solid matter left on evaporating a portion of the water amounted to 40·15 grains per gallon. This consisted of—

| | | |
|---|---|---|
| "'Carbonate of lime ..................... | 23·75 | grains per gallon. |
| Sulphate of lime ..................... | 1·57 | " |
| Sulphate of soda ..................... | 4·33 | " |
| Common salt ........................... | 2·63 | " |
| Carbonate of magnesia............... | 5·18 | " |
| Organic matter and loss ........... | 2·69 | " |
| | 40·15 | grains per gallon.' |

"'Note.—The carbonates of lime and magnesia are kept in solution by the presence of free carbonic acid. If this is neutralised by the addition of lime, a portion is precipitated. By this means nearly one-half the total matters in solution may be removed. Also in boiling the water, before evaporation commences, a portion is precipitated.'

"From the above analyses the high proportion of carbonate of lime will be seen in each case:—

| | | |
|---|---|---|
| "'Analysis No. 1 gave— | Carbonate of lime ................. ...... | 75·26 |
| " No. 2 " | Carbonate of lime ......................... | 84·10 |
| " No. 3 " | Carbonate of lime ......................... | 80·00 |
| | Mean result.......................................... | 79·78 per cent.' |

"From this it appears that the mean result was nearly equal to 80 per cent. of carbonate of lime contained in the fine floury deposit.

"It should be added that at the same colliery there was another range of plain cylindrical externally-fired boilers, which had been working for a number of years, without failing as the new ones had done. The manager, therefore pointed to this fact in support of his view that the new boilers were at fault, and not the feed water, since the feed water appeared to him to be as good in one case as in the other. To settle this question an analysis was made of the water with which the old range of boilers were fed, as well as of the deposit formed within them, in order that a comparison might be instituted, when the following was found to be the result:—

| Sediment. | | Scale. | |
|---|---|---|---|
| "'Carbonate of lime ......... | 22.0 | "'Carbonate of lime ......... | 10·17 |
| Sulphate of lime............ | 63·78 | Sulphate of lime............ | 72·94 |
| Magnesia ...................... | 14·07 | Carbonate of magnesia ... | 15 89 |
| Oxide of iron and alumina | 0·09 | Oxide of iron and alumina | 0·63 |
| Sand, &c. ...................... | 0·06 | Sand, &c. ...................... | 0·37 |
| | 100·00 | | 100·00' |

"The following is an analysis of the water:—

"'A portion of the water, evaporated to dryness, left a residue amounting to 90·3 grains per gallon. This contained—

| | | |
|---|---|---|
| "'Carbonate of lime...................... | 0·15 | grains per gallon. |
| Sulphate of lime ....................... | 16·93 | " |
| Sulphate of soda ....................... | 51·55 | " |
| Common salt ............................. | 2·93 | " |
| Carbonate of magnesia............... | 17·11 | " |
| Magnesia ....... ....................... | 1·22 | " |
| Organic matter and loss ........... | 0·41 | " |
| Total ......... | 90·30 | grains per gallon. |

"'N.B.—As this water is concentrated by evaporation it becomes alkaline.

"'The addition of lime gives a precipate amounting to nearly one-third the total matter solution.

"'Boiling the water causes no precipitate. There was a deposit of organic matter at the bottom of the jar which contained the water.'

"The results of the analyses of the feed waters of the new and old ranges of boilers, as well as the sediment, will be the more easily compared on reference to the following table:—

| | Percentage of carbonate of lime in fine floury deposits. | Grains of carbonate of lime in a gallon of water. |
|---|---|---|
| New Boilers. | | |
| Which failed after six weeks' working ... | 79 78 | 23·75 |
| Old Boilers | | |
| Which worked for years ..................... | 22·0 | 0·15 |

"From this table it will be seen how different were the characters of the waters by which the two ranges of the boilers were supplied, and how much more carbonate of lime was contained in the one that fed the new boilers which failed after six weeks' work, than in the one which fed the old boilers that worked on for years, while it corroborates the view that the failure of the new boilers was not due to their material or workmanship, but to the floury deposit formed by the feed water.

"No. 4. The fourth case of injury to furnace crowns through the use of a feed water forming a fine floury deposit, came under my notice in August, 1867, and occurred in the neighbourhood of Lancaster to a range of three Lancashire boilers, measuring about 28ft. in length, 7ft. in the diameter of the shell, and 2ft. 7½in. in that of the furnace tubes, which were strengthened with T iron hoops at each of the ring seams of rivets, while the blowing-off pressure was about 60lb. per square inch. In this case though the feed water was drawn from a neighbouring stream, which was perfectly clear to the eye, these boilers were found to give repeated trouble at the furnace crowns, the plates bulging down, and the ring seams straining and leaking.

"The fault had erroneously been attributed to the construction of the boilers, in consequence of which the encircling hoops had been removed and the furnaces renewed with ordinary lap riveted plates. This alteration was clearly in the wrong direction, and the plates soon bulged and the seams soon leaked again as badly as ever.

"The accompanying cuts, Figs. 3 and 4, will show the nature of the distortion of the furnace crowns in this case.

"At this juncture I was requested to make an examination, and on getting inside one of the boilers, found that it contained a considerable quantity of light floury deposit very similar to that met with on previous occasions, and already described, while in addition, the feed water was heated by the exhaust steam from the engines, and thus charged with grease. Though a surface blow-out apparatus was fixed to these boilers, it was quite neglected, the connection between the internal collecting trough and the scum tap being broken off, so that

Fig. 3.

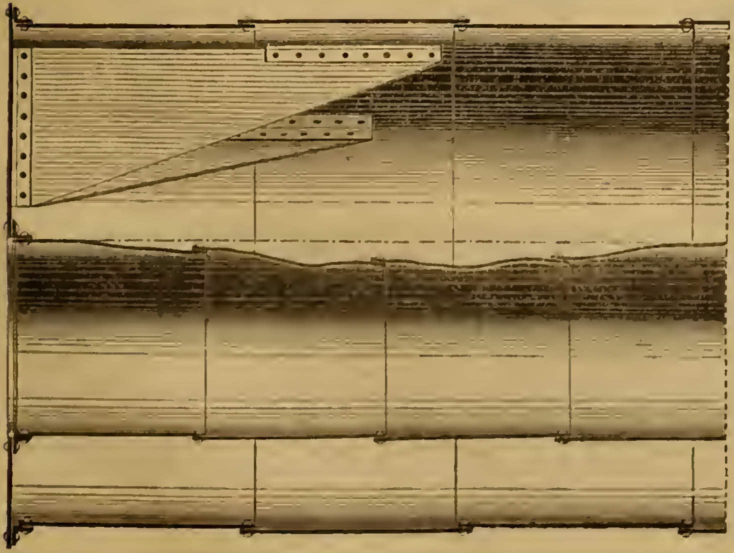
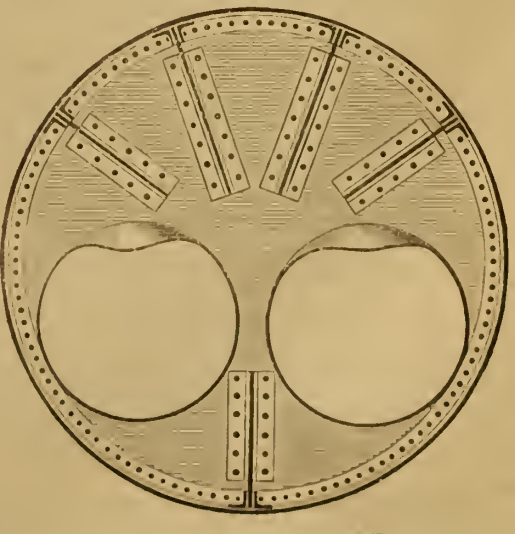


Fig. 4.



it was rendered useless, while the boilers altogether had been very carelessly looked after. These facts were faithfully reported to the manager of the works, coupled with the recommendation that the practice of heating the feed water by the injection of the exhaust steam, should be at once discontinued. But this view of the case by no means proved acceptable. The manager was resolved to have the boilers condemned, and not their treatment or that of the feed water. The following analysis, however, of the feed water and sediment formed by it, shows how similar they were in character to the previous cases referred to:—

| Sediment. | |
|---|---|
| "'Carbonate of lime | 84·210 |
| Sulphate of lime | 1·447 |
| Carbonate of magnesia | 3·991 |
| Iron-peroxide, alumina | 1·811 |
| Silica-sand | 1·441 |
| Moisture and volatile matter | 7·100 |
| | 100·000 |

"'N.B.—The volatile matter seemed to be of an oleaginous nature, and could not well be estimated.'

| Water. | Grains per gallon. |
|---|---|
| "'Carbonate of lime | 11·228 |
| Sulphate of lime | 3·840 |
| Carbonate of magnesia | 2·224 |
| Chloride of sodium | 2·460 |
| Silica | 0·550 |

Total residue, 20·440
Hardness before boiling, 13·5°
„ after „ 4·5°

"'N.B.—The water was clear, slightly acid, and contained but a trace of iron. It has no particular solvent action on iron.'

"Looking at the above analysis there can be no question that the character of the feed water, and the introduction of grease, coupled with the practice of allowing the sediment to accumulate in large quantities in the boilers, was the cause of the injury to the furnace crowns, as in the cases previously referred to, while it may be added in confirmation that after examining these boilers I was informed that one, if not more, of the fusible plugs had been blown out though covered with water at the time, which is a clear evidence that over heating had taken place. Trying, however, as the feed water was in this instance, the injury to the furnace crowns would have been materially reduced, and probably avoided altogether, had the apparatus for blowing out from the surface of the water been kept in good order and regularly used.

"It may also be stated that at the time of my visit I strongly urged that the boilers should be gently fired, since, under the circumstances, hard firing might bring the furnace crowns down in two hours. I had but just returned to Manchester, when the manager wrote me that another of the boilers had failed at the furnace crowns, and the works in consequence were at a standstill. Hard firing is an important element in these cases of injury to furnace crowns with waters containing this fine floury deposit.

"No. 5. The fifth case which may be referred to occurred in Sunderland to a boiler of the patent double furnace conical water tube class, and my attention was called to it in January, 1868. This boiler had been found to fail repeatedly at the plates and seams of rivets in the furnaces, in consequence of which frequent repairs had been had recourse to, and, supposing that the injury to the boiler was due to expansion of the parts, and to too much rigidity, a hoop of bridge rail or horse shoe section had been worked out of Low Moor iron, and introduced at one of the ring seams of rivets in each of the furnaces in order to give elasticity. This, however, proved of no avail, the furnaces again gave trouble and bulged inwards; when some strong stays, lashing the furnaces to the shell were put in, somewhat as in the case of No. 2, and as illustrated in Figs. 1 and 2.

"At this juncture the owner of the boiler, who was a corresponding member of this association, saw me with regard to it, and from his sketch of the shape in which the furnaces had given way, the case appeared very similar to those already mentioned, while it turned out on inquiry that the feed water contained a good deal of carbonate of lime, and that it was heated by the exhaust steam, and thus received the engine sewage. I laid the facts of the previous cases before the owner of the boiler, and on his return he had the feed water changed, when the bulging of the furnace crown ceased, while it may be added, that he found on reference that the difficulty with the furnace crowns had commenced with the use of the feed water in question, so that this afforded a double proof of the cause of the injury.

"No. 6. The sixth case which may be mentioned, and to which my attention was first drawn about March, 1868, gave as much perplexity as any one of them.

"It occurred to any ordinary Lancashire boiler in the neighbourhood of Manchester, while the feed water, which was drawn from a well sunk on the premises, was heated by the exhaust steam from the engine. The boiler measured about 24ft. in length, 6ft. 9in. in the diameter of the shell, and 2ft. 3in. in the furnace tubes, while it was worked at a pressuae of 55lb. on the square inch. This boiler had been originally constructed for experiment purposes, in consequence of which some steam pipes from 10 to 12in. in diameter, were carried through it from one end to the other, which thus served as longitudinal stays to the end plates. As these complicated the boiler, they were removed, and gusset stays substituted for them.

"Shortly after this, the furnace crowns were observed to leak. Whether this had commenced before the removal of the pipe stays just referred to or not, is difficult to ascertain, at all events the owner attributed the difficulty with the furnace crowns to the removal of these pipes and the introduction of gussets in their place. This clearly however had nothing to do with it, though it was not very apparent what was the real cause. After repeated minor repairs however were found useless, the furnace tubes were taken out altogether, the front half of them entirely renewed and strengthened at two of the ring seams of rivets with T iron hoops, while the front end plate of the boiler was also renewed.

"The manner in which the repairs were executed, appeared on examination to be satisfactory, nevertheless, the boiler only worked on a few weeks before leakage again commenced. A consulting engineer was then called in, who gave it as his opinion that the fault was in the workmanship, and that the overlaps had not been well drawn up. The defective seams were therefore again repaired, the old rivets cut out, the holes rimered, and fresh rivets put in.

"Just at the time that the boiler was re-started, a number of practical working boiler makers had a meeting, and discussed the cause of the continued and mysterious leakage that had occurred to this boiler. One of them strongly objected to the encircling hoops, and to these he attributed all the injury, stating that he had a similar boiler under his charge which was never out of trouble, but always leaking and needing repair, while he considered such a boiler was as good as an annuity to the mender, and that the man who was charged to keep the one under consideration in order, would never be in want of a job. At length the meeting unanimously resolved that encircling hoops prevented any expansion of the furnaces, and that it was against all the known laws of nature for boilers constructed in this way to keep tight, and further, that within three weeks, leakage would set in again, and the works would have to be stopped for further repairs. This decision was communicated to the owner of the boiler, and, surely enough, within the appointed time the boiler commenced to leak once more. At this, the owner was quite disheartened, and regretted that he had not had the boiler entirely renewed rather than repaired.

"In a long conversation with the owner at this juncture, it transpired incidentally that when his men first got into the boiler after letting off the water, they found some loose fine dusty deposit within it, when it at once occurred to me that this case might be similar to the others, previously recorded in this report. This had not been suspected before, since the furnace crowns were not bulged out of shape, but merely strained at the seams of rivets, while, in answer to inquiries it had been stated that the deposit altogether was of a very inconsiderable and trivial character. I therefore explained to the owner my suspicions that all the trouble he had experienced was due to the feed water, and recommended him at all events to give the boiler a trial with the Manchester town's water, instead of that drawn from the well, a recommendation, it may be added, that had already been made, as a matter of precaution, but had not been thought worthy of adoption. Though he had no faith in the remedy proposed, it was so simple that he consented to try it. The boiler was at once washed out, and the next morning, started to work with the town's water. From that day the trouble was over. The boiler worked on satisfactorily for several weeks, and after being slightly caulked so as to remove the effects of the old leakages, it was perfectly sound, and though the T iron hoops, which were decided at the meeting of boiler makers to be 'opposed to all the known laws of nature,' had not been removed, the boiler has worked on to this day without giving further trouble, and promises to do so for the next seven years.

"The following is an analysis of the sediment, from which it will be seen that carbonate of lime is the predominating ingredient, though it does not form so large a per centage as it did in the previous cases, which it is interesting to notice in connection with the fact that in this boiler the furnace plates were not bulged, but merely strained at the seams of rivets:—

| | | |
|---|---|---|
| "'Carbonate of lime | | 38·960 |
| Copper | | trace. |
| Carbonate of lead | | 1·790 |
| Sesqui-oxide of iron | | 5·005 |
| Alumina | | 4·456 |
| Sulphate of lime | | 4·490 |
| Carbonate of magnesia | | 1·216 |
| Magnesia | | 11·847 |
| Phosphoric acid | | trace. |
| Chlorine | | trace. |
| Sand and silica acid | | 17·977 |
| Fat | 7·375 | 10·742 |
| Other organic matter | 3·367 | |
| Moisture | | 2·219 |
| | | 98·702 |

"'The deficiency is partly due to the given percentage of carbonate of lead being too small, and to the traces of alkalies, copper, phosphoric acid, and chlorine.'

"When the boiler continued to work on satisfactorily week after week, and month after month, simply by exchanging the well water for the town's water, the owner could not entertaian any further doubt on the subject; and on recollecting the changes made in his work from time to time and remembering how the well had been deepened to increase its supply, he was able to trace a clear connection between the use of the well water and the leakage of the boiler. This shortly received a striking corroboration. In the course of the long drought that occurred in the summer of 1868, the supply of the Manchester Water Works, as all in this locality will remember, began to run short, especially for engine purposes, so that for one afternoon the owner was obliged to fall back on the well water, when, though he tried the experiment for a few hours only, the boiler at once commenced to leak as before, so that he gave up the well water once more, and resolved never to return to it again.

"This case though not so severe as some of the others mentioned, is perhaps the most interesting, from the great perplexity which arose with regard to it, and the conclusive manner in which it was cleared up.

"No. 7. The seventh case was met with near Carlisle, in July, 1868. The boilers, in this instance which were of the ordinary Lancashire type, and strengthened at the ring seams of rivets in the furnaces with T iron hoops, drove a condensing engine, and were fed from the hot well. The length of these boilers were about 30ft., their diameter in the shells 7ft., and in the furnace 2ft. 8in., while the load on the safety-valve was 50lb. per square inch.

"These boilers gave way as in the previous cases at the furnace crowns, in consequence of which the owners reflected on the maker, and the makers, knowing they had delivered sound work, could only account for the failure by supposing that the boilers had been neglected, and the water supply allowed to run short.

"On making an examination I found that the deposit within the boilers was of a fine floury nature, like that already described in the previous instances, though the quantity was not so great, neither were the furnaces so severely distressed. The following is an analysis:—

| | |
|---|---|
| "'Carbonate of lime | 69·39 |
| Iron (peroxide) | 2·17 |
| Alumina | 2·03 |
| Sulphate of lime | 2·39 |
| Carbonate of magnesia | 3·38 |
| Silica and sand | 10·73 |
| * Organic matter | 7·56 |
| Moisture | 2·35 |
| | 100·00' |

"From the above analysis it will be seen that the feed water was very similar to that met with in the other cases previously referred to, though it will be seen that the percentage of carbonate of lime is scarcely so high, which possibly explains the fact stated above that the furnace crowns were less distressed than usual.

"No. 8. The eighth case that may be referred to was met with in August, 1868, and occurred to a couple of boilers laid down near the river Mersey, in the neighbourhood of Widnes. These boilers were of the ordinary Lancashire type, and were but just new, yet they had failed repeatedly at the ring seams of rivets of the furnace crowns, when the old rivets had been cut out, the holes rimered, and new rivets inserted, but without success.

"Under these circumstances the maker of the boilers called upon me, when, in answer to inquiries, it appeared that the feed water was heated by the exhaust steam from the donkey engine, and that the deposit was of a light floury character. I at once recommended that the exhaust should be diverted from the feed water, and on this being done the difficulty with the furnace crowns was overcome. In about a month afterwards the boilers were reported as working satisfactorily, although they had never stood for more than forty-eight hours before.

"The following is an anlysis of the sediment, which, as in previous cases, shows a predominating proportion of carbonate of lime:—

| | |
|---|---|
| "'Carbonate of lime and magnesia | 83·33 |
| Sulphate of lime | 1·17 |
| Alumina and iron | 4·25 |
| Silica | 7·40 |
| Oily matter | 0·25 |
| Organic matter | 3·60 |
| | 100·00' |

"It may be added that further cases have been met with in the neighbourhood of Widnes, and that in December last two other boilers came under my attention, the furnaces of which were bulged out of shape from the same cause as that referred to above.

"It is worthy of note that three different cases of injury to furnace crowns from this fine floury deposit have been met with in the neighbourhood of the Mersey, and within a few a miles of Liverpool.

"I have gone into this subject at some length, because it is one not generally understood. It will be seen that the cases of injury referred to were not confined to any peculiar locality, but were met with in the neighbourhoods of London Lancaster, Carlisle, Birkenhead. Sunderland, Ruabon, Widnes, Manchester, so that they were widely scattered over the country. It can scarcely be doubted that for the want of understanding this subject many cases of misapprehension between boiler owners and boiler makers must have occurred, and the blame of leakage at the seams of rivets in the furnaces, attributed to defective workmanship, or overheating through neglect of the attendants, instead of to the feed water. It is trusted that the general diffusion of information on this subject will prove of practical value to boiler makers and boiler users, and that the number of examples given will be considered sufficient to establish the fact that both in externally and in internally-fired boilers, the plates over the fire may be overheated and bulged out of shape even when covered with water."

## THE BRITISH ASSOCIATION.

## ADDRESS READ BEFORE SECTION G (MECHANICAL SCIENCE SECTION) OF THE BRITISH ASSOCIATION, AUGUST 19, 1869.

By C. William Siemens, F.R.S.

In addressing you from this chair, I feel that I have accepted a task which, however flattering, I should have hesitated to undertake had I not every reason to rely on your forbearance, and on the friendly support of those senior members of our profession who, by their attendance at these annual gatherings, give weight and importance to our proceedings. I also greatly depend on the co-operation of those members of the British Association who, although devoted to the cultivation of physical sciences, are nevertheless ever ready to assist us in our endeavours to apply those sciences to practical ends.

It is by submitting such subjects as will be brought before us to the double touchstone of pure science and of practical experience that we shall be able to appreciate real merit, and at the same time assist the authors of the several papers, by a confirmation or rectification of their views, thus redeeming our proceedings from the inherent disadvantage of lack of time to give that full and patient attention which the authors might meet with in bringing their subjects before the purely professional Institutions of Civil Engineers, Mechanical Engineers, or Naval Architects.

In prefacing our proceedings with a few remarks on the leading subjects of the day of special interest to our section, I can scarcely pass over the somewhat hackneyed question of technical education.

The great international exhibitions proved that, although England still holds her ground as the leading manufacturing country, the nations of the continent have made great strides to dispute her pre-eminence in several branches—a result which is generally ascribed to their superior system of technical education. Those desirous of attaining a clear insight into that system, and the vast scale upon which it is being carried out under government supervision, cannot do better than read Mr. Scott Russell's very able volume on this subject, and they will no doubt agree with the author in the necessity of energetic steps being taken to promote the work of universal education. Although I for one think that objection may fairly be made against the plan of merely imitating the example of our neighbours.

The polytechnic schools of the continent, not satisfied with imparting to the technical student a good knowledge of mathematics and of natural sciences, pretend also to superadd the practical information necessary to constitute them engineers or manufacturers.

This practical information is conveyed to them by professors, lacking themselves practical experience, and tends to engender in the students a dogmatical conceit, which is likely to stand in the way of originality in the adaptation of new means to new ends in their future career. On this account I should prefer to see a sound fundamental education, comprising mathematics, dynamics, chemistry, geology, and physical science, with a sketch only of the technical arts, followed up by professional training, such as can only be obtained in the workshop, the office, or the field.

The universal interest evinced throughout the country in the work of education, by Parliamentary inquiries, by the erection of colleges and professorships, and by the munificence of a leading member of our section in endowing a hundred scholarships, are proofs that England intends to hold her place also in this question of education amongst the nations, and I am confident that she will accomplish this object in a manner in unison with her practical tendencies and independence of character.

Closely allied to the question of education is that of the system of letters patent. A patent is, according to modern views, a contract between the commonwealth and an individual who has discovered a method, peculiar to himself, of accomplishing a result of general utility. The state, being interested to secure the information and to induce the inventor to put his invention into practice, grants him the exclusive right of practising it, or of authorising others to do so, for a limited number of years, in consideration of his making a full and sufficient description of the same. Unfortunately, this simple and equitable theory of the patent system is very imperfectly carried out, and is beset with various objectionable practices, which render a patent sometimes an impediment to rather than a furtherance of applied science, and sometimes involve the author of an invention in endless legal contentions and disaster, instead of procuring for him the intended reward. These evils are so great and palpable that many persons, including men of undoubted sincerity and sound judgment on most subjects, advocate the entire abolition of the patent laws. They argue that the desire to publish the results of our mental labour suffices to insure to the commonwealth the possession of all new discoveries or inventions, and that justice might be done to meritorious inventors by giving them national rewards.

This argument may hold good as regards a scientific discovery, where the labour bestowed is purely mental, and carries with it the pleasurable excitement peculiar to the exercise and advancement of science on the part of the devotee; but a practical invention has to be regarded as the result of a first conception, elaborated by experiments and their application to existing processes in the face of practical difficulties, of prejudice, and of various discouragements, involving also great expenditure of time and money, which no man can well afford to give away, nor can men of merit be expected to advocate their cause before the national tribunal of rewards, where at present only very narrow and imperfect views of the ultimate importance of a new invention would be taken, not to speak of the favouritism to which the doors would be thrown open. Practical men would undoubtedly prefer either to exercise their inventions in secret, where that is possible, or to desist from following up their ideas to the point of their practical realization. If we review the progress of the technical arts of our time, we may trace important practical inventions almost without exception to the patent office. In cases where the inventor of

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* Containing 2·05 of fatty matter.

a machine or process happened to belong to a nation without an efficient patent law, we find that he readily transferred the scene of his activity to the country offering him the greatest encouragement, there to swell the ranks of intelligent workers. Whether we look upon the powerful appliances that fashion shapeless masses of iron and steel into railway wheels or axles, or into the more delicate parts of machinery; whether we look upon the complex machinery in our cotton factories, our dye works, and paper mills, or into a Birmingham manufactory, where steel pens, buttons, pens, buckles, screws, pencil-cases, and other objects of general utility are produced by carefully elaborated machinery at an extremely low cost; or whether we look upon our agricultural machinery by which England is enabled to compete, without protection, against the Russian or Danubian agriculturist, with cheap labour and cheap land to back him, in nearly all cases we find that the machinery has been designed and elaborated in its details by a patentee who did not rest satisfied till he had persuaded the manufactures to adopt the same, and removed all their real or imaginary objections to the innovation. We also find that the knowledge of its construction reaches the public directly or indirectly through the patent office, thus enlarging the basis for further inventive progress.

The greatest illustration of the beneficial working of the patent laws was supplied, in my opinion, by James Watt when, just about 100 years ago, he patented his invention of a hot working cylinder and separate steam engine condenser. After years of contest against those adverse circumstances that beset every important innovation, James Watt, with failing health and scanty means, was only upheld in his struggle by the deep conviction of the ultimate triumph of his cause. This conviction gave him confidence to enlist the co-operation of a second capitalist, after the first had failed him, and of asking for an extension of his declining patent.

Without this opportune help Watt could not have succeeded in maturing his invention; he would, in all probability, have relapsed into the mere instrument maker, with broken health and broken heart, and the invention of the steam engine would not only have been retarded for a generation or two, but its final progress would have been based probably upon the coarser conceptions of Papin, Savory, and Newcomen.

It can easily be shown that the perfect conception of the physical nature of steam which dwelt like a heaven born inspiration in Watt's mind was neither understood by his contemporaries nor by his followers up to very recent times, nor can it be gathered from Watt's very imperfect specification. James Watt was not satisfied to exclude the condensing water from his working cylinder and to surround the same by non-conducting substances, but he placed between the cylinder and the non-conducting envelope a source of heat in the form of a steam jacket, filled with steam at a pressure somewhat superior to that of the working steam. His successors have not only discarded the steam jacket, and even condemned it on the superficial plea that the jacket presented a larger and hotter surface for loss by radiation than the cylinder, but expansive working was actually rejected by some of them on the ground that no practical advantage could be obtained by it. The modern engine, notwithstanding our perfected means of construction, had in fact degenerated in many instances into a simple steam-meter constructed apparently with a view of emptying the boiler in the shortest possible space of time.

It is only during the last twenty years that the subtle action of saturated steam in condensing upon the sides of the cylinder when under pressure, and of evaporating when the pressure is relieved toward the end of each stroke has been again recognised and insisted upon by Lechatelier and others who have shown the necessity of a slightly super-heated cylinder in order to realize the expansive force of steam. The result has been a reduction in the consumption of fuel in our best marine engines from 6 or 8 to below 3 lb. per gross indicated horse power.

Would it be safe in view of such facts as these to discard the patent laws, which, as I have endeavoured to show, lay at the very foundation of our modern progress, without making at all events a serious effort to remedy those evils, which, it is admitted on all hands, now adhere to them? These evils need for the most part no special legislation, but can be traced to the imperfect manner in which the existing patent laws are carried into effect. It is a hopeful circumstance that, during the next session of Parliament, the whole question of the patent laws is likely to be inquired into by a special committee, who, it is hoped, will act decidedly in the general interest without being influenced by special or professional claims. They will have it in their power to render the patent office an educational institution of the highest order.

In viewing the latest achievements of engineering science two works strike the imagination chiefly by their exceeding magnitude, and by the influence they are likely to exercise upon the traffic of the world. The first of these is the Pacific Railway, which in passing through vast regions hitherto inaccessible to civilised man, and over formidable mountain chains, joins California with the Atlantic States of the great American republic. The second is the Suez ship canal, which, notwithstanding adverse prognostigations and serious difficulties, will be opened very shortly to the commerce of the world. These works must greatly extend the range of commercial enterprise in the North Pacific and the Indian Seas. The new waterway to India will, owing to the difficult navigation of the Red Sea, be in effect only available for ships propelled by steam, and will give a stimulus to that branch of engineering.

Telegraph communication with America has been rendered more secure against interruption by the successful submersion of the French Transatlantic Cable. On the other hand, telegraphic communication with India still remains in a very unsatisfactory condition, owing to imperfect lines and divided administration. To supply a remedy for this public evil, the Indo-European Telegraph Company will shortly open its special lines for Indian correspondence. In Northern Russia the construction of a land line is far advanced to connect St. Petersburg with the mouth of the Amoor river, on completion of which only a submarine link between the Amoor and San Francisco will be wanting to complete the telegraphic girdle round the earth. With these great highways of speech once established, a network of submarine and aerial wires will soon follow to bind all inhabited portions of our globe together into a closer community of interests, which if followed up by steam communication by land and by sea, will open out a great and meritorious field for the activity of the civil and mechanical engineer.

But while great works have to be carried out in distant parts, still more remains to be accomplished nearer home. The railway of to-day has not only taken the place of high roads and canals for the transmission of goods and passengers between our great centres of industry and population, but is already superseding bye-roads leading to places of inferior importance; it competes with the the mule in carrying minerals over mountain passes, and with the omnibus in our great cities. If a river cannot be spanned by a bridge without hindering navigation, a tunnel is forthwith in contemplation; or, if that should not be practicable, the transit of trains is yet accomplished by the establishment of a large steam ferry. It is one of the questions of the day to decide by which plan the British Channel should be crossed to relieve the unfortunate traveller to the continent of the exceeding discomfort and delay inseparable from the existing most imperfect arrangements. Considering that this question has now been taken up by some of our leading engineers, and is also entertained by the two interested Governments, we may look forward to its speedy and satisfactory solution.

So long as the attention of railway engineers was confined to the construction of main lines, it was necessary for them to provide for a heavy traffic and high speeds, and these desiderata are best met by a heavy permanent way, by easy curves, and heavy rails of the strongest possible materials, namely, cast steel; but in extending the system to the corners of the earth, cheapness of construction and maintenance, for a moderate speed and a moderate amount of traffic, become a matter of necessity. Instead of plunging through hill and mountain, and of crossing and recrossing rivers by a series of monumental works, the modern railway passes in zigzag up the steep incline, and conforms to the windings of the narrow gorge; it can only be worked by light rolling stock of flexible construction, furnished with increased power of adhesion and great brake power. Yet, by the aid of the electric telegraph, in regulating the progress of each train, the number of trains may be so increased as to produce, nevertheless, a large aggregate of traffic, and it is held by some that our trunk lines even would be worked more advantageously by light rolling stock. The brake power on several of the French and Spanish railways has been greatly increased by an ingenious arrangement, conceived by M. Lechatelier, of applying what has been termed "contre vapeur" to the engine, converting it for the time being into a pump forcing steam and water into the boiler.

While the extension of communication occupies the attention of perhaps the greater number of our engineers, others are engaged upon weapons of offensive and defensive warfare. We have scarcely recovered our wonder at the terrific destruction dealt by the Armstrong gun, the Whitworth bolt, or the steel barrel consolidated under Krupp's gigantic steam-hammer, when we hear of a shield of such solidity and toughness as to bid defiance to them all. A larger gun or a hard bolt by Palliser or Gruson is the successful answer to this challenge, when again defensive plating, of greater tenacity to absorb the power residing in the shot, or of such imposing weight and hardness combined as to resist the projectile absolutely (causing it to be broken up by the force residing within itself) is brought forward.

The ram of war with heavy iron sides, which a few years since was thought the most formidable, as it certainly was the most costly weapon ever devised, is already being superseded by vessels of the Captain type, as designed by Captain Coles, and ably carried out by Laird Brothers, with turrets (armed with guns of gigantic power) that resist the heaviest firing, both on account of their extraordinary thickness, and of the angular direction in which the shot is likely to strike.

By an ingenious device Captain Moncrieff lowers his gun upon its rocking carriage after firing, and thereby does away with embrasures (the weak places in protecting works), while at the same time he gains the advantage of reloading his gun in comparative safety.

It is presumed that in thus raising formidable engines of offensive and defensive warfare the civilised nations of the earth will pause before putting them into earnest operation, but if they should do so, it is consolatory to think that they could not work them for long without effecting the total exhaustion of their treasures already drained to the utmost in their construction.

While science and mechanical skill combine to produce these wondrous results, the germs of further and still greater achievements are matured in our mechanical workshops, in our forges, and in ourmetallurgical smelting works; it is there that the materials of construction are prepared, refined, and put into such forms as to render greater and still greater ends attainable. Here a great revolution of our constructive art has been prepared by the production in large quantities and at moderate cost, of a material of more than twice the strength of iron, which, instead of being fibrous, has its full strength in every direction, and which can be modulated to every degree of ductility, approaching the hardness of the diamond on the one hand and the proverbial toughness of leather on the other. To call this material cast steel seems to attribute to it brittlenesss and uncertainty of temper, which, however, are by no means its necessary characteristics. This new material, as prepared for constructive purposes, may, indeed, be both hard and tough, as is illustrated by the hard steel rope that has so materially contributed to the practical success of steam ploughing. Machinery steel has gradually come into use since about 1850, when Krupp, of Essen, commenced to supply large ingots that were shaped into railway tyres, axles, cannon, &c., by melting steel in furnaces containing hundreds of melting crucibles.

The Bessemer process, in dispensing with the process of puddling, and in utilising the carbon contained in the pig iron to effect the fusion of the final metal, has given a vast extension to the application of cast steel for railway bars, tyres, boiler plates, &c.

This process is limited, however, in its application to superior brands of pig iron, containing much carbon and no sulphur or phosphorus, which latter impurities are so destructive to the quality of steel. The puddling process has still unless the process of decarburisation of Mr. Heaton takes its place, to be resorted to, to purify these inferior pig irons, which constitute the bulk of our productions, and the puddled iron cannot be brought to the condition of cast steel, except through the process of fusion. This is accomplished successfully in masses of from 3 to 5 tons on the open bed of a regenerative gas furnace at the Landore Siemens Steel Works, and at other places. At the same works cast steel is also produced, to a limited extent as yet, from iron ore, which, being operated upon in large masses, is reduced to the metallic state and liquified by the aid of a certain proportion of pig metal. The regenerative gas furnace, the application of which to glass houses, to forges, &c., has made considerable progress, is unquestionably well suited for this operation, because it combines an intensity of heat, limited only by the point of fusion of the most refractory material, with extreme mildness of draught and chemical neutrality of flame.

These and other processes of recent origin tend toward the production, at a comparatively cheap rate, of a very high class material that must shortly supersede iron for almost all structural purposes. As yet engineers hesitate, and very properly so, to construct their bridges, their vessels, and their rolling stock of the material produced by these processes, because no exhaustive experiments have been published as yet fixing the limit to which they may safely be loaded in extension, in compression, and in torsion, and because they have as yet no sufficient information regarding the tests by which their quality can best be ascertained. This great want is in a fair way of being supplied by the experimental researches that have been carried on for some time at Her Majesty's dockyards at Woolwich, under a committee appointed for that purpose by the Institution of Civil Engineers. In the meantime excellent service has been rendered by Mr. Kirkaldy in giving us, in a perfectly reliable manner, the resisting power and ductility of any sample of material which we wish to submit to his tests. The result of Mr. Whitworth's experiments tending to render the hammer and the rolls obsolete by forcing cast steel, while in a semi-fluid state, into strong iron moulds by hydraulic pressure, are looked upon with great interest. But assuming that the new building material has been reduced to the utmost degree of uniformity and cheapness, and that its limits of strength are fully ascertained, there remains still the task for the civil and mechanical engineer to prepare designs suitable for the development of its peculiar qualities If in constructing a girder, for example, a design were to be adopted that had been worked out for iron, and if all the scantlings were simply reduced in the inverse proportion of the absolute and relative strength of the new material as compared with iron, such a girder would assuredly collapse, when the test weight was applied, for the simple reason that the reduced sectional area of each part, in proportion to its length, would be insufficient to give stiffness. You might as well almost take a design for a wooden structure, and carry it out in iron, by simply reducing the section of each part. The advantages of using the stronger material become most apparent if applied, for instance, to large bridges where the principal strain upon each part is produced by the weight of the structure itself; for supposing that the new material can be safely weighted to double the bearing strain of iron, and that the weight of the structure were. reduced by one-half accordingly, there would still remain a large excess of available strength, in consequence of the reduced total weight, and this would justify a further reduction of the amount of the material employed. In constructing works in foreign parts, the reduced cost of carriage furnishes also a powerful argument in favour of the stronger material, although its price per ton might largely exceed that of iron.

The inquiries of the Royal Commission into the extent and management of our coalfields appear to be reassuring as regards the danger of their becoming soon exhausted; nevertheless, the importance of economising these precious deposits in the production of steam power, in metallurgical operations and in domestic use can hardly be over-estimated. The calorific power residing in a pound of coal of a given analysis can now be accurately expressed in units of heat, which again are represented by equivalent units of force or of chemical action; therefore, if we ascertain the consumption of coal of a steam engine or of a surface employed in metallurgical operations we are able to tell by the light of physical science what proportion of the heat of combustion is utilised and what proportion is lost. Having arrived at this point we can also trace the channels through which loss takes place, and in diminishing these by judicious improvement we shall more and more approach those standards of ultimate perfection which we can never reach, but which we should nevertheless keep steadfastly before our eyes. Thus a pound of ordinary coal is capable of producing 12,000 Fahrenheit units of heat, which equal 9,261,000 foot-pounds or units of force, whereas the very best performances of our pumping engines do do not exceed the limit of 1,000,000 foot-pounds of force per pound of coal. In like manner 1 lb. of coal should be capable of heating 33 lb. of iron to the welding point of say 3000° Fahr., whereas in an ordinary furnace not 2 lb. of iron are so heated with 1 lb. of coal. These figures serve to show the great field for further improvement that lays yet before us.

Although heat may be said to be the moving principle by which all things in nature are accomplished, an excess of it is not only hurtful to some of our processes, such as brewing, and destructive to our nutriments, but to those living in hot climates or sitting in crowded rooms an excess of temperature is fully as great a source of discomfort as excessive cold can be. Why, then, may I ask, should we not resort to refrigeration in summer as well as to calorification in winter, if it can be shown that the one can be done at nearly the same cost as the other? So long as we rely for refrigeration upon our ice cellars, or upon importation of ice from distant parts, we shall have to look upon refrigeration as a costly luxury only, but by the use of properly constructed machines it will be possible, I believe, to produce refrigeration at an extremely moderate expenditure of fuel and labour. A machine has already been constructed capable of producing 9 lb. of ice or its equivalent for 1 lb. of coal, whereas the equivalent values of positive heat developed in the combustion of 1 lb. of coal, and of negative heat residing in 1 lb. of ice, is about as 12,000 to 170, or as 70 to 1. This result already justifies the employment of refriegerating machines upon a large scale, but it is hard to say what practical results may yet be reached with an improved machine on strictly dynamical principles, because such a machine seems not tied in its results to any definite limits. In changing, for instance, a pound of water from the liquid into a gaseous state a number of units of heat are required, that may be produced by combustion of coal or by the expenditure of force, but in changing the same pound of water into ice heat is not lost but gained in the operation, which heat must be traceable to another part of the machine, either as sensible heat or as developed force. It would lead me too far to enter at present into particulars on this question, which is one not without interest for the physicist and the mechanical engineer.

There are several other subjects I should have gladly mentioned were I not afraid of encroaching unduly upon your valuable time; these will, I trust, together with some of those I have mentioned, be brought before the section in the form of distinct papers, and will lead to interesting discussions.

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## ROYAL SOCIETY OF EDINBURGH.

### ON THE THERMAL ENERGY OF MOLECULAR VORTICES.

By W. J. MACQUORN RANKINE, C.E., LL.D., F.R.SS. Lond. and Edin., &c.

(*Abstract.*)

In a previous paper, presented to the Royal Society of Edinburgh in December 1849, and read on the 5th of February 1850 (Trans. vol. xx.), the author deduced the principles of thermodynamics, and various properties of elastic fluids, from the hypothesis of molecular vortices, under certain special suppositions as to the figure and arrangement of the vortices, and as to the properties of the matter which moves in them. In subsequent papers, he showed how the hypothesis might be simplified, by dispensing with some of the special suppositions. In the present paper he makes further progress in the same direction, and shows how the general equation of thermodynamics, and other propositions, are deduced from the hypothesis of molecular vortices when freed from all special suppositions as to the figure and arrangement of the vortices, and the properties of the matter that moves in them, and reduced simply to the following form: that thermometric heat consists in a motion of the particles of bodies in circulating streams, with a velocity either constant or fluctuating periodically. This, of course, implies that the forces acting amongst those particles are capable of transmitting that motion.

The principal conclusions arrived at are the following:—

1. In a substance in which the action of the vortices is isotropic, the intensity of the centrifugal pressure per unit of area is two-thirds of the energy due to the steady circulation in an unit of volume. The centrifugal pressure is the pressure exerted by the substance in the perfectly gaseous state.

2. * If there be substances in which the action of the vortices is not isotropic, then in such substances the proportion already stated applies to the mean of the intensities of the centrifugal pressures in any three orthogonal directions.

3. * The proportion which the whole energy of the vortices, including that of the periodic disturbances, bears to the energy of the steady circulation alone, may be constant or variable.

4. Absolute temperature is proportional to the energy of the steady circulation in unity of mass, and to the specific volume in the perfectly gaseous state.

5. In substances which are nearly in the perfectly gaseous state, experiment shows the proportion in which the whole energy exceeds that of the steady circulation to be sensibly constant; and its value may be found by computing in what proportion the dynamical value of the specific heat at constant volume exceeds once and a half the quotient found by dividing the product of the pressure and volume by the absolute temperature. * The following are examples:—air, 1·634; nitrogen, 1·630; oxygen, 1·667; hydrogen, 1·614; steam-gas, 2·242.

6. The known general equation of thermodynamics is deduced from the hypothesis of molecular vortices, * freed from the special suppositions made in the paper of 1849—50.

The new conclusions obtained in the present paper are marked *. Those not so marked were arrived at in the paper of 1849—50.

[The general equation of thermodynamics is here stated for convenience;

let $dQ$ be the thermal energy which must be given to unity of mass of a given substance, in order to produce a given indefinitely small change in its temperature and dimensions: then—

$$dQ = \tau\, d \cdot \phi;$$

in which $\tau$ is the absolute temperature, and $\varphi$ the thermodynamic function. The value of the function is—

$$\phi = Jc \text{ hyplog } \tau \times \chi(\tau) \times \frac{dU}{d\tau}$$

$Jc$ being the dynamical value of the real specific heat; U, the potential energy of the elasticity of the body at constant temperature; and $\chi(\tau)$, a function of the absolute temperature, which is null or inappreciable in a substance capable, at that temperature, of approximating indefinitely to the perfectly gaseous state, and is included in the formula, in order to provide for the possibility, suggested by Clausius, that there may be substances which have not that property at all temperatures].

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

Nitro-Glycerine.—One of the last Acts of Parliament, rendered necessary by the recent fearful accident, was passed to prohibit, for a limited period, the importation and to restrict and regulate the carriage of nitro-glycerine. Save as mentioned, no person, after the passing of the Act, is to bring into any port or harbour of the United Kingdom, or ship or unship on, from, or near the coast of and part of the United Kingdom, any nitro-glycerine. By acting in contravention to the provisions the party is to be guilty of a misdemeanour, and liable to be imprisoned, with or without hard labour, for one year, and all nitro-glycerine brought into any port is to be forfeited. New regulations are to be made as to the manufacture, sale, and carriage of nitro-glycerine, and notice of nitro-glycerine is to be given and search permitted for the article.

Abolition of Patents for Inventions in the Netherlands.—A law has been made cancelling the old patent law of 1817; and though all existing patents remain in force, no new ones are to be any more granted from and after the 1st day of August, 1869.

The Cohahuila (Mexico) Meteoric Irons of 1868.—Mr. J. Lawrence Smith.—It appears that the region of Mexico bordering on Texas has been most profusely furnished with these celestial visitors; six masses, weighing, respectively, 290, 430, 438, 550, and 654 lbs., have been brought to the United States. They are irregular compact masses, without any evidence of stony minerals; they belong to the softer irons, not difficult to cut with a saw. A sample taken from one only of these masses has been as yet submitted to research. Specific gravity, 7·692. It contains, in 100 parts:—Iron, 92·95; nickel, 6·62: cobalt, 0·48; phosphorus, 0·02; copper, a very minute quantity.

Advices have been received that the *Ariel* and *Lahloo* tea ships, left Foo-chow on July 2nd, and the *Leander* and *Thermopylæ* on the following day. The latter two vessels are the favourites in China for the annual "tea race."

A Huge Steam Hammer.—One of the largest, if not the largest, steam-hammer ever made is now being constructed by Messrs. Thwaites and Garbutt, of Bradford, for the Russian Government, and is intended to be used in the forging of steel guns. The total weight of the machine when erected will be close upon 1,000 tons, the anvil block will weigh 500 tons, the other castings belonging to the hammer about 300 tons, and the tup 42 tons.

Drainage of Bromley, Kent.—The inquiry into the vexed question of the Bromley drainage, held before two Government commissioners—viz., Mr. Michael, barrister, and Mr. Harrison, civil engineer—is adjourned until October next. The scheme of the Board of Works to convey the sewage to Holloway Farm for irrigation was opposed by Mr. Boyd, whose park is near the outfal; also by Major Foster. Mr. Coles Child, whose mansion and estate are close by Bromley, visited Ealing, and was so well pleased with what he saw there that he offered to take Bromley sewage on to his land, to be dealt with as at Ealing, the receiving tanks to be within 2,000ft. of his residence, the effluent water to be spread over the field adjoining. The ratepayers were stated to be much in favour of the Ealing system.

It has been said that a little carbolic acid dissolved in the water which is used to moisten a whetstone, or a grindstone, will greatly increase the friction, and thus promote the action of the stone upon the steel instrument. If this be true, and there be no unforeseen drawback, carbolic acid will prove invaluable to all who have to sharpen tools or grind metallic surfaces.

Very Durable Cement for Iron and Stone.—M. Pollack, of Bantzen, Saxony states that, for a period of several years, he has used, as a cement to fasten stone to stone and iron to iron, a paste made of pure oxide of lead, litharge, and glycerine in a concentrated state. This mixture hardens rapidly, is insoluble in acids (unless quite concentrated) and is not affected by heat. M. Pollack has used it to fasten the different portions of a fly wheel with great success; while when placed between stones and once hardened, it is easier to break the stone than the joint.

### NAVAL ENGINEERING.

New Ironclads.—The following armour-clad ships are now under construction for the Admiralty, either at the Royal dockyards or private shipbuilding establishments. They are said to be in such a forward state that they will be completed during the present or early in the ensuing year:—The *Sultan*, 12, 5,226 tons, 1,200 horse-power, and the *Glatton*, 2, 2,709 tons, 500 horse power, double screw turret-ship, building at Chatham dockyard; the *Iron Duke*, 14, 3,774 tons, 800 horse power, double screw building at Pembroke dockyard; the *Swiftsure*, 14, 3,893 tons, 800 horse power, and the *Triumph*, 14, 3,893 tons, 800 horse power, building by the Palmer Shipbuilding Company at Jarrow-upon-Tyne; the *Hotspur*, 2, 2,637 tons, 600 horse power, armour-plated ram, building at the yard of Messrs. Napier and Sons, Glasgow; and the *Vanguard*, 14, 3,774 tons, 800 horse power, building by Messrs. Laird Brothers, Birkenhead. In addition to the above the *Abyssinia*, 4, 1,854 tons, 200 horse power, and the *Magdala*, 4, 2,107 tons, 250 horse power, double screw iron armour-plated turret ships, are building for the defence of Bombay, the former by Messrs. Dudgeon at Poplar, and the latter by the Thames Iron Shipbuilding Company at Blackwall. As soon as one of the building slips becomes vacant at Chatham dockyard a new armour-plated ram, to be named the *Rupert*, of 3,159 tons and 700 horse power, is to be commenced at that establishment. A new armour-plated turret ship, the *Devastation*, of 4,406 tons and 800 horse power, from the designs of Mr. E. J. Reed, C.B., has been recently commenced at Portsmouth dockyard.

The *Journal du Havre* says:—"A gunboat lately constructed at St. Denis by the Emperor's orders, having been armed here with a cannon of twenty-four centimetres (9½in.) calibre, has just gone through a series of experiments between this port and Honfleur. The vessel supported easily a discharge which carried a ball of 238lbs. weight a distance of 8,000 kilometres (five miles). Her draught is only 3ft. 3½in."

### MILITARY ENGINEERING.

A "Yankee Notion."—A man in Adair county, Iowa, has invented a cannon which he believes will send a ball fourteen miles. The peculiarity is in the ball itself, which is in seven sections, with six fuses. The powder of the cannon sends the ball humming two miles from the muzzle, lighting fuse, No. 1, which burns to the powder in the ball in the time the ball travels two miles, when an explosion takes place which sends the ball two miles further, where fuse No. 2 does its duty, and propels the ball two miles further, and so on to the end of the fuses and the fourteen miles.

### RAILWAYS.

Value of the Pacific Railroad Lands.—The value of the land subsidies to the Overland Railroad is worth much more on the Central than on the Union portion of the route. The latter, deducting the worthless portion, have about 6,500,000 acres, from which they will probably realize, their maximum price of 2.50dols. per acre, realizing in gross, 16,250,000dols. The Union Company, although they have built the greater number of miles of the road, and have a larger area of land, will not be able to realize from more than one-quarter of the same—say 2,200,000 acres; which at 2.50dols. will yield them only 5,500,000dols.

Cost on Sleeping Cars.—The charge for sleeping cars on the Central Pacific is 5dols extra for each half section including two seats and a bed for two, from Sacramento to Promontory Point; or 10dols. for seats and beds for four. The cost of passage ticket to the same point is 50dols.—all in gold. The first "Pullman" sleeping and dining car arrived at Sacramento on Thursday evening June 10th.

The Sutherland Railway.—The works on the line of railway between Golspie and Helmsdale are being rapidly proceeded with, a great part of the earthworks being completed. A heavy cutting has to be made between Golspie Station to a short distance north of Dunrobin, a distance of about two miles, with a gradient of 1 in 60, which has been commenced. There is also to be a bridge over the burn of Dunrobin, a height of seventy or eighty feet, with six or seven culverts. The line runs nearly in a straight line from Golspie Station to the Dunrobin Saw-Mills, passing between them and the road, and crossing the present road a little to the north. The present road, however, is to be shifted nearer the Castle, and will then form nearly a straight line between the two lodges. This cutting will be very expensive, but owing to the peculiar circumstances under which the works are carried on, it will be perhaps the cheapest line ever constructed. Commonly railway lines are made by one contractor, who almost invariably realises a large profit; but in the present case, there are only a few small contracts given. The larger part of the work is carried on by His Grace the Duke of Sutherland, under the superintendence of experienced men, and it is believed that the result will prove highly satisfactory in an economical point of view.

Steam Engines.—The value of the exports of steam engines made from the United Kingdom has somewhat revived this year, having amounted, to May 31, to £645,771, as compared with £569,953 in the corresponding period of 1868, and £778,038 in the corresponding period of 1867. The value of the steam engines—probably for the most part locomotives—sent to Russia has largely increased this year; on the other hand, there has been a rather material decrease in the case of British India.

The report of the Brazilian Street Railway Company (limited) presented on the 30th ult., stated that the first six months' working since the line was taken over by the company had exceeded that of the first half of 1868 by nearly a third, and proposes a dividend at the rate of 10 per cent., leaving £747 to be carried forward. The actual profit was at the rate of 14 per cent. per annum, and would have been 18 per cent. but for the depression in the rate of exchange, consequent on the Paraguayan war. An extension of two and a half miles, which can be effected for £10,000 within a few months, was strongly recommended, and it was proposed to issue new shares to the amount of £20,000 for that and other purposes.

### LAUNCHES.

On the 21st ult., there was launched from Mr. John Elder's Fairfield shipbuilding yard, Govan, an iron paddle-wheel steamer, of 1,125 tons burden, and 250 horse-power nominal. She is named the *Lee Nanzing*, and is intended for the China trade.

Launch of an Inman Liner.—The steamship City of Brussels, the most recent addition to the celebrated Inman line of Atlantic steamers, was lately launched from the building-yard of Messrs. Tod & Macgregor, at Partick. The dimensions of the vessel are:—Length over all, 406ft.; beam, 40ft.; depth, 28ft. 6in. Her tonnage is 3,000, and her engines (constructed on the horizontal trunk principle) are of 600 nominal horse power, capable of indicating 3,300 horse power. Like the *Great Eastern*, she has steam-steering gear, in addition to the ordinary machinery, for controlling her course. Accommodation is provided for 200 first and 600 second and third class passengers.

### DOCKS, HARBOURS, BRIDGES.

A New Canal.—Monsieur Lesseps proposes to cut throught the Isthmus of Corinth, which will shorten the journey from Marseilles to Constantinople by fourteen hours, and that from Trieste to the same town by twenty hours. The length of the canal would be two miles and a-half, and the expense, if commenced next spring, only 12,000,000f., as a large number of the workmen now employed on the greater works at Suez could be transported at a trifling cost to the scene of the contemplated undertaking.

The New Bridge at Saltburn-by-the-Sea.—This bridge, which spans the well-known Skelton beck glen, is just finished. The whole of the ponderous girders, 85ft. in length, are now fixed, and the roadway laid. The bridge is 800ft. in length, there being seven spans and eight cast-iron piers; the highest point is 160ft. and the width is 25ft. The contractors are Hopkins, Gilkes, & Co., of Middlesbrough who have had Mr. Charles Willman, C.E. as chief superintendent.

The *Malta Times* of the 19th of August contains the following:—"Letters from Alexandria (Egypt) dated 14th inst. state that the Nile continues steadily to rise, and it is expected that the navigation of the canal will in a few days be opened for large boats. when abundant supplies of produce may be looked for. About the growing crop of cotton it is as yet too early in the season to form any opinion of any value: but it may be mentioned that the rising of the Nile is satisfactory, and that the cotton plants thus far look strong and healthy. The export of cotton from the 1st of October last to the 13th of August was 217,536 bales. Freights by steamer to Liverpool ½d. to ⅝d. per pound and 20s. to 25s. per 40 cubic feet for steam pressed bales; for grain 5s. 9d. per 460 lb. By sailing vessels 5s. 3d. to 5s. 6d. per 480lb. for grain; 29s. to 30s. per ton for cotton seed to the United Kingdom. Exchange on London P., 96½ to 96¾ per £1 sterling."

### TELEGRAPHIC ENGINEERING.

Telegraphy in the West Indies.—A short time ago the junction of Cuba with the mainland of the North American continent suggested the extension of the lines to others of the West India Islands. Gradually assuming greater magnitude, the scheme now comprises the construction of cables from Cuba to Panama through Jamaica, from Jamaica to Porto Rico and St. Thomas, thence through the chain of the West India Islands to Georgetown, New Amsterdam, and Surinam, on the South American continent. A link from St. Thomas to Bermuda will bring the new cables into direct connection with the Atlantic Cable which it is proposed to lay from the south of Spain through the Azores and Bermuda to Richmond, in the United States. Negotiations are in progress for the extension of telegraphic communication with Peru, Chili, and the Argentine Confederation, and the Brazilian Government has resolved on continuing the lines from Surinam round the coast to Rio Janeiro, so that communication will be thus effected between the new system and the lines completed or in course of construction from Rio to Monte Video, Buenos Ayres, and Valparaiso.

### ACCIDENTS.

Terrible Explosion of Nitro-Glycerine.—A letter from Rio Janeiro says that owing to the bad reputation of nitro-glycerine, a small quantity in the military arsenal there was ordered to be thrown into the bay. Six 10-lb., cans were put into a boat, and taken out 250 yards. The first one thrown out exploded on striking the water, and the concussion set off the others. The boat was blown to pieces, and all the crew—seven persons—killed.

Accident on the Baroda Railway—Eleven Persons Killed.—We regret to learn that a serious accident occurred on the Bombay, Baroda, and Central India Railway on the 28th July, near a place called Etola, about 10 miles south of Baroda. The through passenger train from Ahmedabad to Bombay ran into a bullock which had strayed upon the line, the result being that several carriages were overturned, two-storeyed second-class carriages smashed, eleven passengers killed, and seven injured—one seriously. What a commentary is this on the following passage from Colonel Strachey's report on railway accidents in India during 1868, which has just been published. Colonel Strachey, it may be well to mention, is secretary to the Government of India, in the Public Works Department. He says;—"The fencing on these lines requires attention. It is known to have been deliberately neglected on the Bombay, Baroda, and Central India Railway."

### MINES, METALLURGY, &c.

A new copper mine has been discovered in South Australia, between Port Augusta, and the Blindman. Some rich specimens of carbonates and oxides have been taken from the surface of the ground, and a splendid lode, of immense width, is reported to be traceable for several hundred yards. The finder, Mr. Thomas Flett, has been offered £4,000 for his discovery.

A new auriferous strata has been discovered in that part of Siberia traversed by the affluents of the Angara, at a distance of about 250 miles from Tenisseisk.

### APPLIED CHEMISTRY.

M. Dubois Caplain has patented an improvment in refining metals. Instead of leading the vapours and gases disengaged during the process simply into water, he introduces fine wrought iron shavings into the chambers for their reception and condensation. He also brings them in contact with a jet of steam situated in the line of draught. Under the combined action of the steam and iron, the vapours of the sulphuric and sulphurous acid are decomposed and sulphate of iron is formed which passes off in a state of solution. The reaction will be the same whatever metal may be substituted for the iron, although the product may be different, that is if the metal can be attacked by sulphuric acid.

Sugar and Starch from Sweet Potatoes.—M. H. Barton presented, at a meeting of the Franklin Institute, samples of sugar and starch, and the following analysis made in November last, from the juice of North Carolina sweet potatoes (per cent);—Sugar, 10·50 starch, 6·00; various salts, 1·17; gum, &c., 0·33; water, 82·00. By the use of powerful presses, 90 per cent of the weight of the potato can be obtained in juice: the density of this juice is 10° Beaumé = 1·075 sp. gr. These potatoes, the author says, will yield 6·18 per cent of sugar and 5 per cent of starch; but by improved culture, as evidenced in Europe in the instance of beet-root, this quantity may be largely increased.

Tinning by the Moist Way.—Dr. Hillier—It is a well-known fact that, when it is desirable to cover metals, especially brass or copper, with a strongly-adhering coating of tin, this is usually effected by boiling the articles to be thus coated with an aqueous fluid, to which is added cream of tartar, crystallised protochloride of tin, and some lumps of pure metallic tin. The author states that, instead of this mixture, he uses, with very good success, a solution of 1 part of protochloride of tin in 10 parts of water, to which he next adds a solution of 2 parts of caustic soda in 20 parts of water; the mixture becomes turbid, but this does not affect the tinning operation, which is effected by heating the objects to be tinned in this fluid, care being taken, at the same time, to place in the liquid a piece of perforated block-tin plate, and to stir up the fluid during the tinning with a rod of zinc.

On the Varieties of Tapioca and Sago Prepared in the Malaccas.—It appears that, at the request of the resident Governor of the Malacca Islands, researches have been instituted concerning this food, at the Laboratory, at Welte Vreden, Java. The authors of this paper, MM. Major, Moens, and Scharlee, found that three varieties of sago, denominated white, red, and blue, contain, respectively—water, 16·14, 18·83, and 18·17, per cent; protein compounds, respectively—3·7, 2·5, and 2·4 per cent; starch, fat, &c., respectively—79·88, 78·08, and 78·15 per cent; ash, respectively—0·22, 0·32, and 0·91 per cent.

### LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 76 | 0 | 0 | ,, | ,, | ,, |
| Tough cake and tile do. | 74 | 0 | 0 | ,, | ,, | ,, |
| Sheathing and sheets do. | 79 | 0 | 0 | 80 | 0 | 0 |
| Bolts do. | 77 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 81 | 0 | 0 | 83 | 0 | 0 |
| Old (exchange) do. | 65 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7 | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6½ | 0 | 0 | 6¾ |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. to arrive | 20 | 15 | 0 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | 26 | 10 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 123 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 124 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 131 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 135 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 130 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 8 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 14 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 2nd quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. Coke do. | 1 | 2 | 6 | 1 | 4 | 0 |
| IX. do. do | 1 | 8 | 6 | 1 | 10 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 15 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 15 | 0 | ,, | ,, | ,, |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 0 | 0 |
| Bars do. do. | 7 | 7 | 6 | 8 | 0 | 0 |
| Hoops do. do. | 8 | 0 | 0 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | 6 | 5 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 7 | 5 | 0 | 7 | 10 | 0 |
| Do. Swedish in London do. | 9 | 17 | 6 | 10 | 0 | 0 |
| To arrive do. | 10 | 0 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 12 | 6 | 3 | 3 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 5 | 0 |
| Do. in faggots do. | 15 | 15 | 0 | 16 | 0 | 0 |
| English spring do. | 19 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 10 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 15 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | ,, | ,, | ,, |
| Spanish do. | 18 | 10 | 0 | ,, | ,, | ,, |

*At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated July 20th, 1869.

2194 A. Stansfeld — Apparatus for propelling on land, &c.
2195 S. Hall—Artificial fuel
2196 J. H. Johnson—Dyeing
2197 H. Higgins and T. S. Whitworth—Preparing cotton
2198 G. Finnegan—Sawing wood
2199 J. Ellison—Rope, &c.
2200 H. B. Clark—Horse rakes

### Dated July 21st, 1869.

2201 J. W. Laimuth — Connecting together the ends of hoops
2202 J. Duke—Ships
2203 J. Ogden—Combined tap and filter for water, &c.
2204 W. R. Lake—Marline spikes
2205 W. Brookes—Spinning carded wool
2206 G. Follett — Waterproof facing for brick buildings
2207 G H. Ellis—Rotary engines
2208 A. H. Brandon—Springs applicable to railroad cars
2209 G. Allibon and A. Manhre—Improvements in steam boilers
2210 J. Boyd—Winding yarn
2211 A. C. Kirk—Abstracting heat
2221 J. H. Johnson—Extract from hops
2213 H. E Newton—Brad driver
2214 M. Tildesley—Ties, &c.
2215 A. M. Clark—Carding engines
2216 F. M. Mole—Matchets
2217 H. Knight—Clipping horses
2218 G. T. Abbey—Firearms

### Dated July 22nd, 1869.

2219 J. Dawson and T. C. Fawcett—Improvements in raising gigs
2220 W. Currie—Heels of boots
2221 W. H. Gosling—Sewing machines
2222 J. Rowley—Coal tar products
2224 J. Green—Ropes, &c.
2225 W. Warren—Anchors
2226 W. Bull—Velocipedes
2227 W. A. Gilbee—Preserving the aromatic principle of hops
2528 W. Dennis—Letter boxes
2229 W. K. Stock—Looms
2230 J. Walsh—Hoods for invalid perambulator and other vehicles
2231 J. G Wilson—Velocipedes
2232 R. Boyd—Boilers, &c.
2233 T Barnes—Treatment of coal
2234 J Hayward—Combs
2235 W. R. Lake—Telegraph wire insulators
2236 W. Laing—Washing machines

### Dated July 23rd, 1869.

2237 W. Morris—Points or switches for tramways
2238 W. Lincolne and E. Chafer—Manufacture of artificial marble
2239 E. Stevens—Cooking, &c.
2240 J. H. Johnson—Joints of pipes
2241 J. H. Johnson—Purifying alcohol
2242 G. T. Bousfield—Harness motion for power looms
2243 S. Bishop—Lamps
2244 S. Cotton—Hackling flax
2245 W. Mort—Refrigerating apparatus

### Dated July 24th, 18.9.

2246 I. Frankenburg and S. Phillips—Manufacture of hats
2247 H. Greaves—Permanent way of railways and tramways
2248 W. Dredge and A. Stein — Propelling carriages
2249 R. Pictet—Pumps, &c.
2250 J. Dewe—Mail bags
2251 C. L. Caldesi—Collars, &c.
2252 G. N. Blaue—Mortising timber
2253 R. G. Lowndes and J. Reid—Manufacture of textile fabrics
2254 T. Auchincloss-Heating feed water
2255 C. Y. Michie and G. W. Murray—Pillars or standards, &c.
2256 W. Tongue—Furnaces
2257 D. H. Brandon—Metallic cartridges

### Dated July 26th, 1869.

2258 W. Crossley and J. W. Swithenbank—Shuttles
2259 T. Winter—Combing reeds
2260 J. Holding—Looms
2261 J. G. Rollins—Combined reaping and mowing machines
2262 J. Hyde and J. Hyde—Safety lamp for preventing explosions
2263 E. Attenborough—Looped fabrics
2264 B. Hunt—Valves
2265 C. Cochrane — Preparation of iron ores for smelting
2266 W. W. Roberts—Furniture
2267 E. Giuder—Firearms
2268 W. E, Tilley—Coating iron
2269 J. H. Johnson—Treatment of night soil and other waste products
2270 R Shaw and R. Lakin—Improvements in carding engines

### Dated July 27th, 1869.

2271 J. Miller—Mariners compass
2272 C Henderson—Girders
2273 M. J. Frisbie—Carriage axles
2274 J. Winslup—Preparation of mendicaments for external and internal use
2275 I. Barker—Coffered spades
2276 T Parsons—Engine to be used in measuring water, &c.
2277 D. T. Bostel—Earth closets
2278 J. Windle—Rolling hoops
2279 W R. Lake—Shearing animals
2280 A. M. Clark—Refining sugar

### Dated July 28th, 1869.

2281 W. A. Lyttle—Electro telegraphic apparatus
2282 D. A. Fyfe—Manufacture of paper
2283 H. Gillan and G. Crawford—Spinning or twisting tobacco
2284 F. Crossley—Preventing metals from rusting
2285 A. V. Newton—Grinding knives
2286 A. Burdess—Winding up watches

### Dated July 29th, 1869.

2287 H. A. Bonneville—Looms
2288 H. A. Bonneville—Weaving looms
2289 H. S Herman—Waste of flax converted into substitutes for cotton
2290 A. Smith and D. Cunningham—Refining crude mineral oils
2291 J. Tate—Scutching flax
2292 D. R. Kilpatrick—Springs
2293 W. E Gedge—Lubricating
2294 T. F. Taylor—Metal tubes

### Dated July 30th, 1869.

2295 J. S. Kipping—Fixing colours
2296 T. W. Lockyer—Ladies' bustles
2297 W. R. Lake—Block calendars

### Dated July 31st, 1869.

2298 G. Allibon—Steam engines
2299 A. Patene, F Bardoux, and G. Julie—Reproducing wood
2300 J. B. B. Pinchon—Condensing steam
2301 C. Watts and T. Watts—Indicating stations to passengers
2302 D. Stewart—Apparatus for concreting sugar cane juice
2303 F. Jackson—Improvements in lubricators for steam engines
2304 J. M. Clements—Improvements in sewing machines
2305 C N. Eyland—Improvements in buckles for articles of dress
2306 B. Goddard and W. Finley—Mixing substances for pills
2307 J. C. Milns and J. Sandiford—Pins, pirns, or bobbins
2308 H. S. Edwards—Gearing for auxiliary steam engines
2309 T. Ramsay—Improvements in the manufacture of gas
2310 J. Beckett—Self acting breaks for railway carriages
2311 W. R. Lake—Improvements in direct acting engines

### Dated August 2nd, 1869.

2312 S. M. Smith—Dyeing certain textile fabrics
2313 P. R. Hodge—Manufacture of luminous and heating gas
2314 J. Sharrocks—Engines, &c.
2315 L. W. Wright—Paddle wheels
2316 W. Hosack—Extracting saccharine juice from sugar cane
2317 F. A Yeo—Machinery for manufacture of artificial fuel
2318 M. Henry — Ventilating mines, drains, and other places

### Dated August 3rd, 1869.

2319 J. Pinchbeck-Gas meters
2320 H. Turner—Expansive condensing steam engines
2321 C. D. Abel—Converting reciprocating into rotary motion
2322 E. Beanes—Process for re-working wrought iron
2323 A. Louden—Taps used for drawing off water, &c.
2324 T. Grace—Stoppering bottles
2325 W. E Gedge—Currycomb
2326 C. Tuer, R Howarth, and J. Pimbley—Polishing threads
2327 J. T. Way—Manufacture of manures and purification of gas
2328 J. T. Way—Manufacture of soap and cleansing wool
2329 J. Bapty and A. Hall—Mechanism for spinning wool
2330 I. Davies—Improvements in rotary gas exhausters

### Dated August 4th, 1869.

2331 T. Livesey and T. Abbott—Mode of boiling size
2332 E. H. de Bodmer—A new kind of carriage wheels
2333 F. C. Culney—Mechanism for propulsion of vehicles
2334 G. Broadhurst — Waterproof coats, capes, &c.
2335 G. S. Hazlehurst—Communication between passengers, guard, &c.
2336 J. Booth and R. W. Morrell—Improved textile fabric
2337 W. T. Ramshill—Construction of heels for boots
2338 G. C. Ramsey—Circular boxes
2339 J. Taylor—Device for balancing toilet and other glasses

### Dated August 5th 1869.

2340 A. Tylor—Regulating and adjusting standards of measure
2341 J. Elce and R. Bond—Self acting temples for looms
2342 W. Brown—Machinery for rolling rails and girders
2343 G. W. Murray and G. M. Garrard—Ploughing land
2344 J. U. Fairbairn—Improvements in the construction of velocipedes
2345 E. Beanes—Improvements in preserving articles of food
2346 B J. B. Mills—Meters for measuring liquids and gases

### Dated August 6th, 1869.

2347 E. Cocking—Easy chairs, &c.
2348 E. Ridoux—Life preserving dress
2349 J. Garde and A. Garde—Improved ventilating hat
2350 B. Hunt—Numbering register
2351 W. B. Rust—Portfolio for the preservation of letters
2352 C. J. Chubb — Boring holes in coal, hard ground, &c.
2353 T Leach—Composition for coating the bottoms of iron ships
2354 W. R. Lake—Devices for holding the chimneys of gas burners
2355 W. R. Lake—Improvements in expanding drills

### Dated August 7th, 1869.

2356 W. Tongue—Machinery for generating elastic vapours
2357 E. W. Hawes—Buoys, &c.
2358 W. Manwaring—Harvesting machines
2359 D. Ridge—Eccentric lever polygonal boring brace
2360 G. Nickerson—Apparatus for raising straw, &c.
2361 W. Guest—Preparing cotton and other fibrous materials
1362 H Brandreth—Arrangement and construction of cutter, &c.
2363 I. Brown—Improvements in irrigating land, &c.
2364 W. E. Newton—Process for purifying or disinfecting alcohol
2365 J. Mitchell—Quilts
2366 A. B. Ibbotson—Joints for securing together railway rails
2367 W. R Lake—Machine for sowing and covering seed
2368 W. R. Lake—Machinery for combing fibrous materials
2369 J T. Greenfield—Life buoys
2370 G. Ritchie—Tents and sunshades or weather protectors
2371 A. C. F. Franklin—Lubricating apparatus for screw propeller

### Dated August 9th, 1869

2372 G Rastall—Velocipedes
2373 J. Quinton—Tobacco pouch
2374 S. Osborn—Knives for reaping and mowing machines
2375 J. Staniar, S. Dawson, and E. Davies—Dressing grain, &c.
2376 J. Froggatt—Pickers employed in the process of weaving
2377 J. H. Johnson—Manufacture of felted fabrics, &c.
2378 C. F. Brooman—Means for carrying or storing eggs
2379 A. Turner—Utilising waste strips of india rubber
2380 H. Wimshurst—Improvements in marine propellers
2381 G. F. Ansell—Improvements in the manufacture of iron
2382 W. R. Lake—Improved apparatus for adding numbers

### Dated August 10th, 1869.

2383 E. A. Cuiley—Effective application of reciprocating motive power
2384 R. Longdon—Refrigerators for preserving food
2385 T. Haucox—Rolling metallic axles for wheels, &c.
2386 C. Lockman—Sewing cloth, an improvement on sewing machines, &c.
2387 E. T. Hughes—Construction of rock boring machinery
2388 C. W. Zeuger, C. L. Strube, and L. Merlett—Globular cylinder manometer with double capillary lock
2389 S. Hutchinson—Machinery for striking out leather
2390 J. E. Holmes—Cutting stone
2391 T. S. Blair—Improvements in the manufacture of iron
2392 T. S. Blair—Treatment of conglomerates of cast iron
2393 J. Caddick—Candlesticks
2394 F. Mazet—Match box candlestick
2395 S. J. Woodhouse—Purifying and regulating the supply of gas
2396 W. Wright—Knobs, &c.
2397 H. Bessemer —Fusion of metals
2398 C. D. Watson—Waterproofing fabrics
2399 A. H. Brandon—Cartridges

### Dated August 11th, 1869.

2400 J. Tenwick—Lubricators
2401 A. B. Brown—Hydraulic printing or copying presses
5402 J. B. Austin—producing and applying black, &c, patterns of needlework, on vellum, cloth, &c.
403 C. Crossley and R Whipp—Manufacture of size
2404 J. Cross—Dry soap for washing, &c
2405 G. White—Pipes for smoking tobacco
2406 F. H Needham—Apparatus to be applied to casks or other vessels containing liquid, to preserve the liquid while on draught
2407 J. Mayer—Improvements in hoop skirts
2408 A. M. Clark—Improvements in the manufacture of phosphate of ammonia
2409 J. H. Johnson—Improvements in the manufacture of iron and steel

### Dated August 12th, 1869

2410 J F. E. Martin—Improved construction of submarine and other tunnels
2411 W. Davis—Stamping, crushing, and grinding ores, and such like substances
2412 J. Parrish—Improvements in the construction of skips, hampers, and other baskets
2413 D. Barker—Improvements in the manufacture of artificial fuel
2414 W. E Newton—Improvements in centrifugal pumps
2415 J. Deas and G. Rapier—Lifting jacks for lifting railway rails
2416 W. R. Lake—Improvements in machinery for charging gas retorts

### Dated August 13th, 1869

2417 H Hudson—Apparatus for effecting communication between railway passengers, guards, and engine drivers
2418 D A. Gibbs—Covering the sides and bottoms of ships and vessels
2419 E. J. Grubham—Plaiting or folding textile fabrics, &c.
2420 C E. Brooman—Treating the waste of wool, silk, horn, &c, to be used as manure
2421 E. J. Hill—Signalling apparatus
2422 T. Beckwith—Reaping and mowing machines
2423 I. E. Woolf—Casters
2424 J. Cowan—Soap
2425 J. Lewis—Extracting copper from its ores
2426 J. Hampton—Velocipedes
2427 W. Richards—Breech loading fire-arms

### Dated August 14th, 1869.

2428 T. Sagar—Looms for weaving
2429 J. Kenyon—Consuming fuel
2430 L. D Newell—Preventing sea sickness
2431 W. Matt—Imitation of marble
2432 H. T. Yates—Production of cops and spoles
2433 T. Coad—Sewing machines
2434 S. Smith—Common road carriages
2435 E. H. C Monckton—Harvesting and preserving
2436 J. B. Rushbrook—Hurdle
2437 G. Ash—Artificial teeth

### Dated August 16th, 18 9.

2438 T. Ward and W. S. Black—Twisting tobacco
2439 J Mitchell—Improvement in kilns
2440 H. Pinkus—Furnaces
2441 J. Blyde—Scissors or apparatus for gathering flowers and fruit
2442 H. Dupland—System of coatings against dampness and saltpetre
2443 J. G. Dale and E. Milner—Producing white pigments from lead
2444 G Sunderland and R. J. Midgley—Spinning and doubling or twisting worsted, silk, or other fibrous substances
2445 H. A Bonneville—Charging and discharging fuel in gas retorts
2446 H. H. Trenor—Automatic passenger register
2447 S. Harvey—Indicating signals
2448 F. Ransome—Artificial stone
2449 J. Lawson and E. G. Fitton—Spinning flax, hemp, jute, and tow

### Dated August 17th, 1869.

2450 T. J. Leigh—Furnaces
2451 R. H. Charsley—Improved carriage for locomotion by manual labour
2452 H. B. Barlow—Dressing or preparing hides
2453 J. Eastwood—Churning milk
2454 B. Hunt—Spinning yarns of flax, &c.
2455 J. Williams—Maps
2456 M. H. Jacobi—Galvanoplastic process for depositing iron
2457 R. F. Fairlie—Improvements in locomotive engines and carriages
2458 J. H. Johnson—Manufacture of iron
2459 W. R. Lake—Penholders
2460 W. R Lake—Machine for making sewing needles

### Dated August 18th, 1869.

2461 J. Checketts—Window blind
2462 J Jenkins—Lining the interior of casks
2463 J. Prato and F. Polacco—Charcoal filters
2464 J. Mackenzie—Machinery for sowing seeds
2465 E. T. Hughes—Boots and shoes
2466 A. Brown—Ground or earth screws
2467 T. Parkinson—Admission of air to furnaces
2468 E. T Hughes—Looms for weaving
2469 R. F. Fairlie—Injectors for feeding steam boilers with water
2470 J. Lewis—Spring sackings
2471 G. Metcalf—Furnaces
2472 J. Watson—Presses
2473 J. Mitchell—Forging, &c.
2474 H. Whiteside—Turret clocks

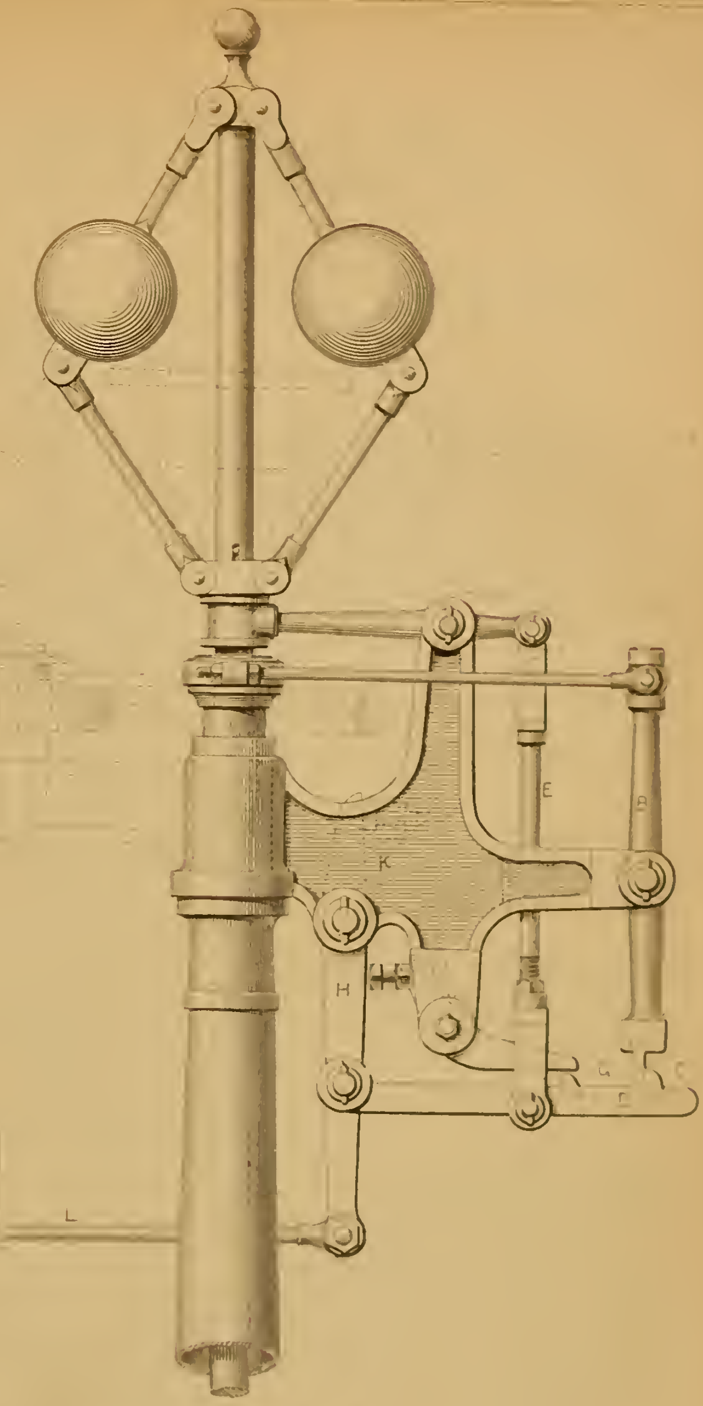
### Dated August 19th, 1869.

2475 M. Wilson—Bird cages
2476 J. and J. E. Mayall—Motive power
2477 W. Campion—Sewing machines
2478 A Gilchrist—Slide valves
2479 H. N. Moyou and J. E. Lemercier—Coverings for the feet
2480 W. N. Hutchinson—Locomotive engines
2481 J Blakey—Utilising waste leather
2482 F. Braby—Caustic ammonia
2483 W. Jones—Sewing machines
2484 S. Robinson—Glass houses
2485 J. Jones—Electro magnetism as a motive power
2486 W. R. Lake—Screw propellers

# UMPHERSTON'S

# GOVERNOR CUT-OFF GEAR.

SCALE TO FIG. 1. [illegible] INCH = 1 FOOT



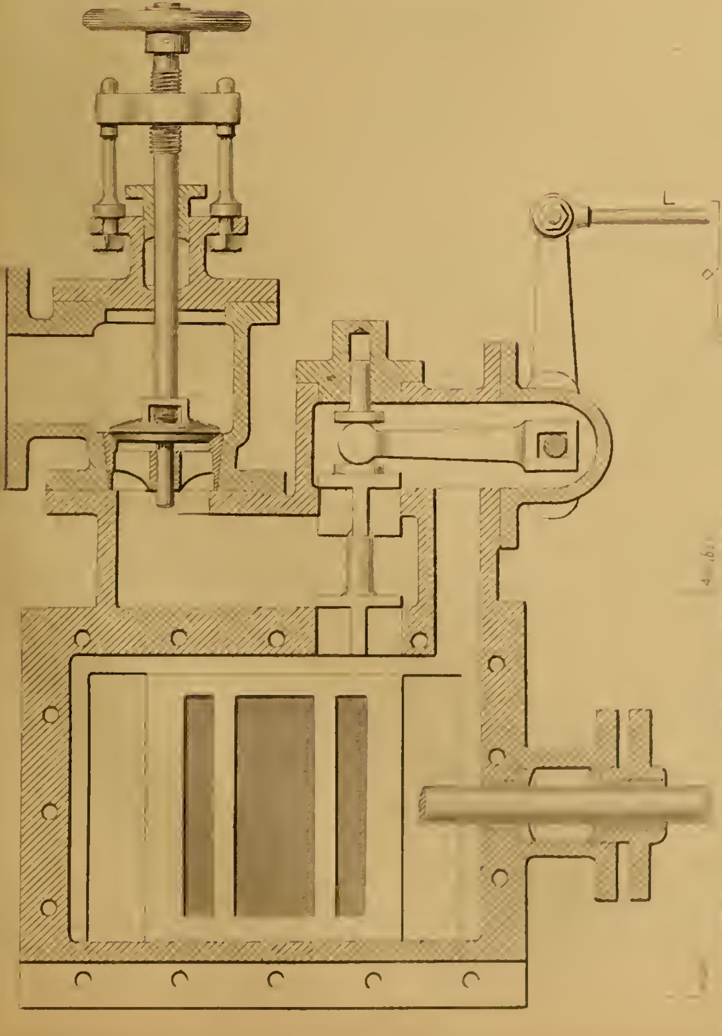


FIG. 1.

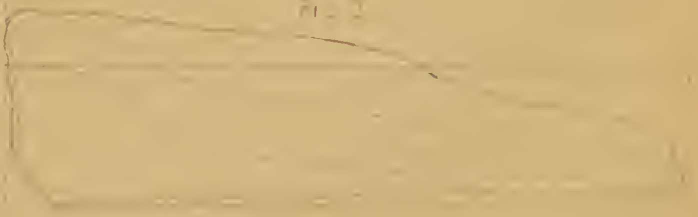


FIG. 2.

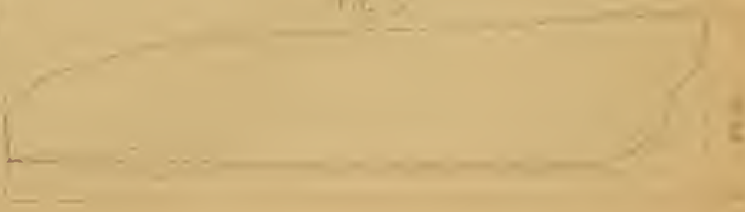


FIG. 3.

W. Smith, C.E. direx.

# THE ARTIZAN.

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## UMPHERSTON'S GOVERNOR CUT-OFF GEAR FOR STEAM ENGINES.

(*Illustrated by Plate* 353.)

We have lately drawn the attention of our readers to several different forms of steam engine governors, which have had for their object the more perfect regulation of the speed of the engine. In the case of the governor designed by Mr. Umpherston, and illustrated by Plate 353, the object sought to be obtained, is not only perfect regularity of speed but also economy of steam, by adapting the governor to work a peculiar description of cut-off gear.

The following description of this governor was read before the Institution of Engineers in Scotland :—

Steam engine governors and throttle valves to regulate the supply of steam so as to maintain an uniform speed, have received much attention from engineers, and throttle valves can be constructed and worked by the common governor so as to maintain a very uniform speed under ordinary circumstances.

The effect of a throttle valve is to reduce the pressure of the steam upon the piston less or more,except when the engine goes too slow, in which case only the full pressure of steam is allowed to act upon the piston; the loss of pressure at other times by "wire-drawing" the steam is a loss of power worth consideration.

Several methods are at work for admitting at all times the full pressure of the steam upon the piston, the quantity admitted being regulated by the governor so as to maintain an uniform speed under a varying burden; but none of these are yet in general use.

The arrangement now to be described is a simple and efficient method of maintaining, without a throttle valve, an almost perfectly uniform speed however variable the burden on the engine may be; while at the same time the steam may be worked at any degree of expansion.

This arrangement may also be attached to any common sort of engine without alteration of its valve gear. To regulate the supply of steam, an auxiliary cut-off valve is used, which should be placed as close as possible to the slide valve. The sort of cut-off valve preferred is an equilibrium valve the same as now often used for a throttle valve. The discs do not shut steam tight against seats, but simultaneously as they pass into the short cylinders. Sufficient travel is given to this valve, so that it may move as long after shutting as it moves while open.

This valve must open and shut twice for each revolution of the crank shaft, and may receive its motion from a small eccentric upon the governor spindle, if the governor be geared to make two revolutions for each revolution of the crank shaft; or the double action of the valve may be obtained in any other more convenient way.

This valve may be set to shut in advance of the slide valve, at some point of the stroke corresponding to the average burden upon the engine, and so long as the burden and speed do not vary, this valve will continue in constant action; but by its connection with the governor its action is stopped, leaving the valve shut for an instant, when the speed increases; and is stopped, leaving it open, when the speed is reduced or continues slow.

One arrangement is shown on Plate 353, Fig. 1, to illustrate how this action of the cut-off valve is suspended by the governor.

The valve receives its opening motion from the eccentric, A, which makes two revolutions for each revolution of the crank shaft, and gives a constant motion to the lever B, and so long as the catches at C are in contact, the valve will continue to be regularly opened by the lever, B, and shut by its weight or by a spring or weight, if necessary. The lever, D, carrying the two under catches, is connected with the governor by the rod, E, and the lever, F. The upward and downward movements of the governor give downward and upward movements to this lever, D. The downward movement of this lever, D, disengages the catches at C, and the cut-off valve is thus left shut until the governor resumes its proper speed. The upward movement of this lever beyond its middle position, brings the second catches at G into contact, the upper one of which is jointed upon a fixed pin, and so adjusted to the other that it rises when the under one presses against it; and, when the under one has reached the end of its travel, and passed the upper one a little, the latter will fall and prevent the movement of the other, so long as the governor continues to keep the lever D above its middle position; and while in this position, the cut-off valve will remain open and steam will thus be allowed to flow into the cylinder, so long as the slide valve will permit. The quantity of steam thus admitted being greater than when the cut-off valve is in action, will increase the speed of the engine or enable it to overcome some additional burden at a reduced speed; but as soon as the governor can regain its right speed, the catches at G will be disengaged, and the catches at C will again come into action as before.

The resistance which the governor has to overcome in working these catches is very small, and thus it is more easily affected by any slight variation of speed. The range of action upwards or downwards on the governor, required to work these catches, is very little, and thus the slightest increase or decrease of speed will instantly suspend the action of the cut-off valve, leaving it entirely shut, or fully open; and this maximum variation in the quantity of steam admitted produces an instantaneous and imperceptible correction of the speed.

By using a cut-off valve of the kind described, the power required to work it is very little indeed. All the working parts of this arrangement may be light, and can be easily adjusted and kept in good working order.

This cut-off gear is now working satisfactorily upon some large engines, and the accompanying diagrams, Figs. 2 and 3, show its action upon two of these. One is a high-pressure engine working against a back pressure of steam; its cylinder is 27in. diameter, and the stroke 6ft.—the other is a condensing engine with a 40in. cylinder and 6ft. stroke, worked by steam, which is supplied to it at a very low pressure. The middle line in both diagrams shows the action of the steam when cut off by the auxiliary valve; the upper line shows the effect when the cut-off valve is kept open and the steam is admitted until cut off by the slide valve; and the under line shows the effect when the cut-off valve is kept shut.

If the burden and steam pressure be nearly steady, the point of cut-off may be adjusted so near to the average burden, that the cut-off valve will only miss its action once in ten or twenty revolutions of the engine.

If the burden be suddenly increased or wholly thrown off, the maximum or minimum quantity of steam is as suddenly supplied, and any variation in the speed is only perceptible by the small movement of the governor required to work the catches.

Besides the many cases in which this gear may be applied with advantage to land engines, it may also be advantageously applied to marine engines, working screw propellers, when the construction of the engines will admit of a cut-off valve being introduced between each cylinder and the steam pipe.

No special construction of governor is necessary for working this cut-off gear, and any other construction of cut-off valve which may be found more suitable, under special circumstances, may be used and worked by a similar arrangement to the one now described.

In applying this cut-off gear to old engines, the advantage of working the steam expansively can only be partially obtained, as such engines are usually so burdened in proportion to the size of the cylinder, that even although the initial steam pressure might be somewhat increased, yet the quantity required to overcome the burden, is more than can be used economically in so small a cylinder.

In proportioning a new engine, this cut-off gear may be arranged to cut off at a very early part of the stroke, and with very little space for steam between the cut-off valve and the slide valve.

Plate 353 shows the arrangement of valves which has been applied to a new horizontal engine with the valve on the side of the cylinder.

## THE TOWER SUBWAY.

This remarkably successful piece of engineering is fast approaching completion, just at the time when the old Thames Tunnel has been closed for general traffic. Unlike its predecessor, the new tunnel has been made at a very small outlay, and consequently promises to be not merely an engineering but also a commercial success. This subway was begun on the 16th of last February (singularly enough the 45th anniversary of the day of commencing the old Thames Tunnel), and is expected to be open for public traffic in November next. Thus it will have taken only nine months to complete instead of 12 years, and its cost will be less than £16,000, as compared with about £450,000. Mr. Barlow's new tunnel is simply a circular iron tube, seven feet in diameter, taken deep under the river and in London clay, which is itself impervious to water. Whatever the differences between the two tunnels, that which is now nearly finished must always be regarded as an engineering marvel, for the strength and simplicity of the structure and the cheapness and rapidity of its construction. That other such under-stream bridges will soon follow upon the success of this we have not the least doubt; but with Mr. Barlow, senior, must always remain the credit of originating the idea, and with Mr. Barlow, jun., the present engineer of the tunnel, the merit of having carried it out without the slightest hitch or accident, and, with the aid of Mr. Greathead, the contractor, entirely within the estimated cost.

The sits of the works of the new Thames Tunnel on Tower-hill does not attract much notice from passers by. It is a little hoarded space about the size of an ordinary kitchen, with a small steam crane in the centre—and this is all. No doubt the company would have liked more, but they could not afford it. This portion of Tower-hill is Crown land, and either the Government did not choose to encourage a tunnel which was not much believed in at first, or thought that the indulgence in such a luxury ought to be well paid for—at all events, they charged the company for a piece of ground about 10 feet square for their shaft, a price which was at the rate of about £150,000 an acre, with a further fine of about £10 a yard for tunnelling under Government ground, and £3 a yard for tunnelling under the bed of the river on their side. In fact, the Government altogether take about one-tenth of the very modest capital subscribed for the whole enterprise. The Board of Works on the south side of the river, where the station is to come out, near Tooley-street, have been more just, or, rather, not so rapacious, for they have only charged only about £200 for the site of the shaft. Inside the hoarding on Tower-hill is a circular iron shaft, ten feet in diameter and 60 feet deep. The upper part of the shaft is lined with rings of cast iron, the lower part with ordinary brickwork, which will hereafter be coated with glazed tiles so as to throw a light to the bottom of the shaft. The tube or tunnel has very much the appearance of one of the large clean main drainage sewers, except that it is built of iron and has a greater incline, viz., about 1 in 40. The tunnel is designed on a plan to keep it always well in the London clay, and thus from the north to the south shores it makes a dip to pass under the greatest depth of water of the river. At its nearest point to the river water it has a thickness of not less than 22ft. of London clay between the bed of the river and the top of the tube, while at its furthest point it has a thickness of not less than 32 feet. In spite of this thickness of clay, however, which is of all others the worst conductor of sound, a person can hear the regular beat of the steamers passing up and down the water overhead. The recent explosion of a steamboat near Tower Wharf was not only heard but even felt in all parts of the tunnel.

The way the tube tunnel is built is by means of three segments of a circle of cast-iron, each weighing 4cwt., with a centre key-piece at the top, weighing 1cwt. Each segment or ring when bolted together is only 18 inches long, but no fewer than six of these rings are bolted on in every 24 hours, so the tunnel is advancing at the rate of nine feet a day. As the shield, which is 7ft. 3in. in diameter, is pushed on for a length of 18in. it leaves within its tube or rim a space one inch greater all round than that occupied by its own tube on the outside. This, therefore, leaves ample room to fit in the segments of the tunnel tube easily. This is done very rapidly. The bottom segment is laid in its place, and the two side segments above it and between these at the top the key-piece is slid in. Between the long horizontal flanges a layer of white pine is placed before they are screwed close up. The spaces between the circular flanges of each segment are regularly caulked in with tow and cement. Still, the shield or cap is one inch wider all round than the diameter of the tunnel tube within it which comes afterwards to occupy it, leaving an opening of that space between the clay and the iron. This interstice, when the segment ring is fixed, is closed by pumping in blue lias cement, which, as it quickly sets, forms a ring of stone work, preventing the action of the water on the iron tube. The tube is to be fitted with a tramway of 2ft. 6in. gauge, on which is to run a light iron omnibus of 10½ft. long, 5ft. 3in. wide, and 5ft. 11in. high. This will accommodate 14 people with the most perfect ease. Ordinary lifts will take them down and up the shafts at either end, and at the end of the shaft the "bus" will be waiting. For the first hundred feet or so the omnibus will be pulled by a rope fixed to a stationary engine; after that it will descend by its own velocity down the incline and up the incline on the other side to the foot of the shaft. The whole transit, including time for descent and ascent, is calculated not to exceed three minutes, which, with a working day of 16 hours, and allowing for the omnibus not always being full, would give about 5,000 to 6,000 passengers a day, who at the rate of 1d. a head would give a net revenue to the company such as ought to pay an immense dividend on the small capital of the company on passengers alone, exclusive of the charge upon parcels. There is, however, not the slightest reason why, if the traffic increases, two omnibuses should not be run together, instead of one, for as long as they are together, and nothing but themselves in the tunnel, collision becomes a physical impossibility.

## NEW BLACKFRIARS BRIDGE.

This bridge, a general account of which was given in The Artizan for last June, being now very nearly completed, a few additional remarks may perhaps be of interest.

The length of each pier is about 110ft., their width at water-level averaging 25ft. at base and 20ft. at springing. The cutwaters are about 130ft. long. In every pier, at the level of the springing of the arch above the cutwater, and resting upon a handsome flowing base of Portland stone, are massive polished red granite columns from the Isle of Mull. Their average height is 10ft. 6in., and their diameter is not less than 7ft. Formed of three blocks, each block weighing from 10 to 14 tons, these squat pillars are, architecturally, out of all proportion. The Portland stone capitals, viewed apart, have great merit of design; but those pieces of sculpture cannot well be reconciled with the dumpy strength of the gigantic red columns. The slender water-fowl, the very emblems of ethereal lightness, interpose their fragile forms between the superincumbent masonry of which they are the immediate support and the sturdy posts that seem designed to carry the weight of the bridge itself, merely uphold the semi-octagonal recesses jutting out from the footways. There can be but slight question that, on the cutwaters of a bridge, massive pillars like these are misplaced. The abutments at both ends of the bridge rise with the bold solidity of Egyptian monuments; and their broad flat tops suggest, if indeed they do not bespeak, the intention to crown them with sculpture. By the use of iron the crown of the bridge is lightened, as in the case of Westminster. The outer iron spandrils of the arches are covered at the intersections of the lattice work with large ornamental bosses, much after the pattern of the heraldic rose. These decorations are to be gilt; and the whole bridge will be rich in colour-contrasts; for the ironwork is painted a rich bronze green that shows well with the deep red of the granite columns, and with the white of the carved stone. From the inside of the bridge the parapet seems rather low, its height being only 3ft. 6in.; but, seen from the river, it has a good bold, lofty appearance; an effect due to its position on the summit of a rich cornice. From the same point of view, the towering abutments, rising to a height of nearly 60ft. above the shore, are not undeserving of the epithet grand.

The paving of the bridge is being admirably executed, in accordance with improved methods. Mallet's buckle-plates support the roadway and footpaths. For the former a foundation of Kentish rag mixed with asphalte is 18in. deep upon the plates; and the footpath, with its kerbs and channels, is Guernsey granite. The flags of the footpaths are magnificent slabs of stone, of unusual thickness. The lamps will stand a little back from the kerb stone, and, being raised to a very graceful and imposing elevation, will afford light to the navigation of the river as well as to the traffic on the bridge.

## SHAW'S GUNPOWDER PILE DRIVER.

We illustrate below a gunpowder pile driver, which is now attracting a good deal of attention in America, where it has had a very successful trial. The machine is constructed of heavy wood framing, as in the ordinary pile driving machine, and provided with a cylinder head of cast-iron K, resting on the top of the pile C, and guided by the iron rails N: the cylinder is bored out on its upper end for the reception of a plunger S, of the hammer H, and is cast concave on its lower end for the reception of the pile C. The hammer H is guided by the rails N, and is bored on its upper end for the reception of a piston I. It is cast with a V-groove for the reception of a friction rod M, Fig. 2. The piston and rod I are connected with a cross beam, firmly fixed at the top of the frame, where a rope pulley F is also placed for the convenience of hoisting the piles into position. The friction rod M is connected with the starting lever O, and also with short cast iron arms pivoted to brackets L, Figs. 1 and 2, for the purpose of pressing tightly against the V-groove in the hammer, as shown in Fig. 2, whenever the hammer moves in a downward direction. A ring is made of steel and screwed on the end of plunger S; this ring, though of solid steel, expands under this pressure, the same as hydraulic packing, and makes a tight and durable packing.

FIG. 1.

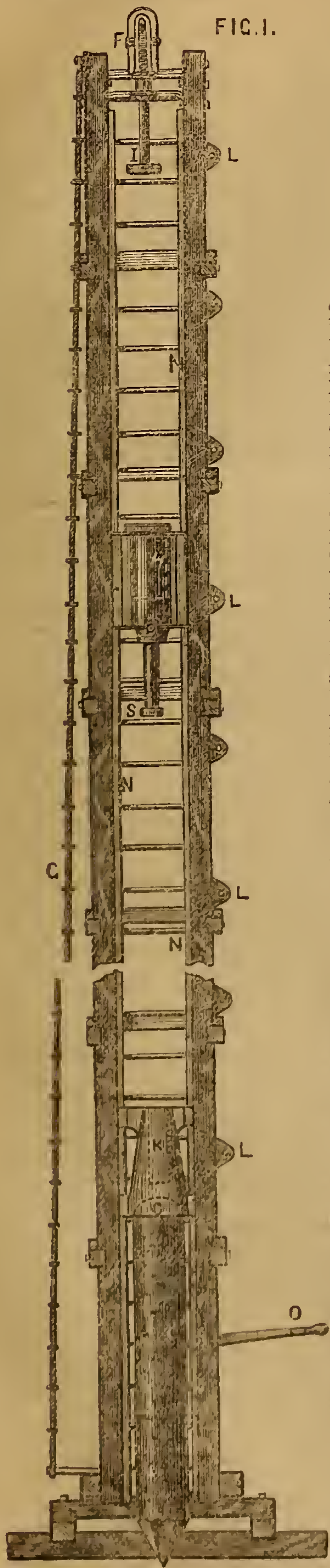
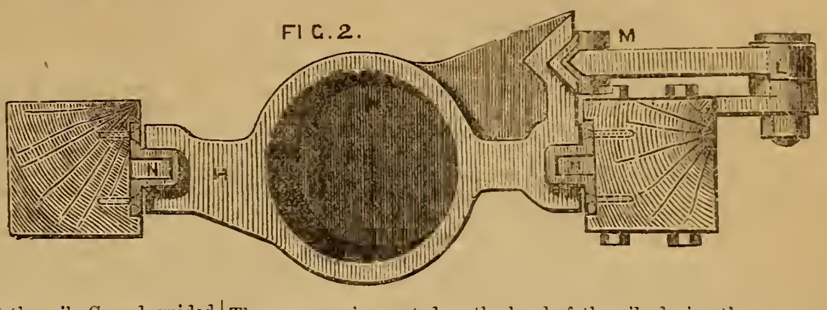


FIG. 2.



The machine is operated and controlled by a man and boy; the latter is stationed at the rope ladder G, and throws a cartridge of powder into the cylinder K. The hammer is allowed to drop by the man's pressing upon the lever O, which elevates and releases the friction rod from the hammer and causes it to drop, forcing its plunger into the cylinder, compressing and heating the air contained therein sufficient to ignite the powder, whenever the plunger comes in contact with the powder. The explosion of the powder elevates the hammer, and the recoil of the cylinder forces the pile into the ground. When the cartridges are thrown at the rate of fifty per minute the hammer is operated without the use of the lever, except when desiring to cease operating.

The object of the air cushion at the top, formed by the bore in hammer H and piston I, is to prevent a heavy charge from injuring the machine.

The powder employed is of the most simple character, being composed of one and a-half parts of chlorate of potash and one part of bituminous coal, both pulverised and mixed through an ordinary sieve. This powder burns very slowly in the open air; a barrel full might be ignited without causing any report. The charges of powder are exceedingly small, a charge of one-third of an ounce being employed to throw a hammer of 675lbs. weight, and is stated by the *Scientific American* (whence this description is taken) that it exerts a force on the head of the pile equal to a dead weight of 300,000lbs. for a temporary period. The pressure is exerted on the head of the pile during the presence of the plunger in the cylinder; this gives a blow and pressure of the character of the hydraulic press with the rapidity of the hammer: hence the pile can be driven more rapidly, and forcibly, and firmer, without in any way injuring or splintering it, as in the common method of driving. The usual wrought iron ring, secured to the head of the pile preparatory to driving, is in this method entirely dispensed with, and it is estimated that even this trifling advantage will nearly pay for the powder employed.

A committee of engineers, composed of W. W. Wood, Chief Engineer of the United States Navy; H. L. Hoff, of the Eagle Ironworks, Philadelphia; and T. J. Lovegrove, Inspector of Steam Boilers, Philadelphia, appointed to investigate the operation of this invention, give a most flattering report, indorsing fully all of the above statements.

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## PATENT LAW.

### The Bovill Litigation.

(*Continued from page* 200.)

Since this history was commenced the policy of the Patent Laws has been the subject of discussion in the House of Commons, in the *Westminster Review*, and in some pamphlets. We believe that our Patent Law, properly administered, would be valuable as a stimulus to invention and protection to merit. As it has been administered in the Court of Chancery it has been a hindrance to trade and afforded a premium to unscrupulous pretenders to bear down opposition by the ruinous cost of litigation. It is not a little remarkable that the patents mentioned by Sir Roundell Palmer as illustrations of the mischief of patents were all litigated in Chancery. Sir Roundell considers that that Court has been proceeding according to law, and having regard to the results exhibited in Hill's Patent, Young's Patent, and Bovill's patent, that that law ought to be repealed. We believe that that Court did not proceed according to law—at least, in this sense, that if the patents had been litigated at law, the results would have been widely different—and the conclusion we should advocate would be, that the Court of Chancery should be deprived of all jurisdiction in patent litigation. We suggest to the opponents of patents that they should inquire, what decisions by Courts of Law have made patents odious. It is worth their consideration whether the objectionable characteristics of patents are not all of them traceable to the manner in which they are dealt with in Chancery. If (as we anticipate) we shall succeed in showing that that Court has failed miserably when some of its most eminent judges dealt with patent cases, and that failure is attributable to the method and course of the Court itself, it would surely be wise before deciding that the inconveniences preponderate over the advantages of patents, to try the practical working of patents on the administration of the law by the Courts at Westminster only.

In Sir R. Palmer's memorable speech, he brought out with remarkable force and clearness the absurd conclusion of the Court of Chancery upon Bovill's Patent. He described Bovill's invention as the discovery of the precise measure of exhausting power which should be used by millers, and his argument was that the Law of Patents was mischievous in allowing such a patent, when it was unquestionable that several millers had been using exhaust before Mr. Bovill took out his patent, and it was absolutely certain that some of them must sooner or later have of necessity made the same discovery. We should be surprised if in this description Sir R. Palmer was stating his own view of Mr. Bovill's invention. It is, however, an accurate description of the views expressed by Lords Cairns and Hatherley upon that subject. Sir Roundell urged—this being the law, it is mischievous, therefore abrogate that law. We say, on the contrary, if the Court of Chancery could propound any such statement of the Law of Patents, let it be deprived of jurisdiction over that subject much more should it be excluded from that field if (as we shall show it has done) it can decide that a patent is for the invention of the precise line and measure at which the exhaust should be used, but is infringed although that line and measure be not observed by the miller. Lord Hatherley described the invention as "a delicate arrangement, delicate in one sense but not delicate in another;" and in this sentence he pithily expressed the principle, or absence of principle, on which the Court of Chancery has throughout acted in regard to Bovill's Patent. The invention has always been considered as extremely delicate when the Court has been inquiring whether prior uses of the exhaust had anticipated the patent, but as by no means delicate when investigating the alleged infringement.

The quantity of litigation in Chancery upon Bovill's Patent has become almost cause of complaint, but when it is known that, up to the present hour, that Court has never considered the question whether Mr. Bovill's specification disclosed any invention properly so called, and has never had before it any evidence that what it was pleased to consider the invention, was of the slightest utility, or that any practical man would gather from the specification that that was the nature of the invention, or could, from the instruction afforded by that document, carry that invention into practice, the quality of that litigation will be fairly estimated.

We suppose that the writer of the article on "Patents, Patentees, and the Public," in the last number of the *Westminster Review*, must have formed his opinion of the nature of Mr. Bovill's invention, much in the same way as Mr. Howard, M.P., did—without once reading the specification for himself; but, after all the discussion the subject has received, it is refreshing to find that in pages of such authority the public may learn that Mr. Bovill's invention was one of adjusting the millstones themselves so as to increase their power and yet prevent the diffusion of stive in the mill! We must now proceed with our narrative.

Mr. Bovill moved before the Master of the Rolls for a new trial of the issues in Bovill *v.* Goodier, and Mr. Justice Willes wrote his opinion of the verdict in these terms:—

"Common Pleas, 17th Jan., 1867.

"My dear Lord Romilly,—Certainly I expected a different result upon the Issues as to novelty.

"Mr. Potto Brown and the Isleworth Mills were the most important topics for the defendant. I own that, without impeaching the credit of the witnesses, I thought the result of their evidence was short of an anticipation of Bovill's discovery, considered as consisting of the regulated or proportioned exhaust.

"I write this on the spur of the moment, but, as I anticipated this question, you may take this to be my formed opinion.

"If you wish to speak to me upon the case, I shall be happy to wait upon you. "Yours very faithfully,

"The Lord Romilly, &c., &c." "J. S. Willes."

"P.S.—This cause was very much cramped for time, but this is one of the misfortunes common to everybody during the Winter Circuit.—J.S.W."

One of the jury made an affidavit purporting that he was unaware of the effect the verdict in the form it was given would have upon the patent. In Westminster Hall a juror's affidavit would not be permitted to be read, but Lord Romilly considered the Court of Chancery not fettered in that way, and appears to have persuaded himself that the verdict was a mere slip, and did not express the deliberate conviction of the jury, and he thus discoursed on granting the new trial:—

"Lord Romilly: In this case of Bovill *v.* Goodier, I am of opinion that there must be a new trial.

"I proceed solely upon the ground that, in my opinion, the verdict of the jury is against the weight of the evidence. Not only was the evidence called to my attention very fully and distinctly in the course of the three days' very elaborate argument which took place before me, but I have also examined it as carefully as I could, in order to arrive at the proper opinion and view that I should take upon the subject. I concur with Mr. Justice Willes in saying that I think the evidence which is given on behalf of the defendant does not show an anticipation of Mr. Bovill's Patent.

"Now, I do not think it necessary—indeed I do not think it desirable or proper—that I should go into the detail of the evidence to say upon what grounds I have come to that conclusion. Mr. Justice Willes came to the same conclusion, which he has stated in his letter to me. I have come to that conclusion also. I do not think that the evidence shows an anticipation of Mr. Bovill's patent, and, having come to that conclusion, I am of opinion that I could not satisfactorily, in a Court of Equity, make any Decree, in consequence of that, without further investigation.

"I beg also to state that I express no opinion whatever—it is unnecessary that I should—with respect to the affidavit of the juror, and the circumstances which took place in the jury room. I think, as I said before, that it is necessary the Court should hear the affidavit for the purpose of exercising its judgment, upon whether such a case is made out as to induce a Court of Equity to interfere; for I am of opinion that a case might be made out which would induce this Court to interfere. I do not, therefore, express any opinion upon the subject, and I think it desirable to leave that untouched.

"I am of opinion that there must be a new trial, on the ground I have stated, that the verdict in my opinion, is against the weight of the evidence given in favour of the plaintiff. I think you have copies of the letter of Mr. Justice Willes to me, so that I need not give you the original.

"Mr. Grove, if you try the case you must do it speedily—if you go on with it."

The great case of Bovill *v.* Crate was the next incident. It was before the Vice Chancellor Sir W. Page Wood (now Lord Hatherley) for 15 days. Judgment was pronounced 14 June, 1867, at such great length that we must content ourselves with extracts showing the views of that distinguished judge as to what are the rights of a patentee, the functions of the Court of Chancery in a patent cause, and how evidence is to be put aside.

But we must do the Court the justice of saying that a very unfortunate attempt was made to prove a matter of fact which was wholly irrelevant to the real controversy, namely, to prove that there could not be a plenum of air in the case of millstones working without wind in the ordinary manner.

This attempt withdrew the attention of the Court from the true significance of the terms of the specification. It led the Court to conclude that the question was, "Is there in ordinary millstones cases that condition of air which can be properly called plenum?" instead of the true question, "Is Mr. Crate using an exhaust which relates to the plenum of air forced through the millstones?" Lord Hatherley seems never to have divested himself of this mistake as to the character of the invention. The central idea with him has all along been "Is there a plenum of air in the millstone case?"

The judgment begins with a discussion of the question of fact whether there is in the ordinary working of millstones a blowing action in the rotating stone; and a statement of the three extant claims of the specification; and after noticing that a question had been raised whether the first claim did not vitiate the patent, it proceeds:—

"Then comes the second part of the invention, as the inventor calls it, which is the important point on which I have to determine this case. 'In carrying out the second part of my invention when working millstones with a blast of air, I introduce a pipe to the millstone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber as hereafter described, by which the dust in the mill is avoided and the grinding improved. And this part of my invention relates only to sucking away the plenum of dusty air forced through the stones and not to employing a sufficient exhausting power to induce a current of air between the millstones without a blast, this having before been practised as above mentioned.' Now one must first see where it is that he describes any invention at all. Certainly it cannot be taken he described the invention until you come to the latter sentence I have just read—'and this part of my invention relates only to sucking away the plenum of dusty air.' It cannot be said he describes there any claim for invention until you come to this portion; for not only does he say this part of my invention relates only to this thing, but further than that, anterior to that passage, he has described how he applies the invention. He applies it 'when working millstones with a blast of air,' and 'he introduces a pipe to the millstone case from a fan or other exhausting machine.' He mentions that, as it was mentioned in Bovill v. Keyworth, as a thing that was perfectly well known *per se*—that is to say, any exhausting machine you like to use—so as to carry off all the warm dusty air" (this is the second occasion on which the learned judge quoted these words without completing the sentence 'forced through the stones,' being the immediate context) "to a chamber; and then he says, it relates to this 'the sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the millstones without a blast."

We pause here to observe that he omits to notice the expressed reason "that having before been practised," and that the necessity for a blast of air to force a plenum of air through millstones does not appear to have suggested itself to his mind. One would have anticipated that an analysis of the patentee's language so well commenced would have been persevered in as far as the inquiry whether, as "no invention had been described until you come" to this passage, these words do themselves describe an invention within the law of patents. That cardinal point has not been considered by any judge of the Court of Chancery, and Lord Hatherley having shown conclusively that no invention had been described before these words, at once diverged into another topic. He proceeded—"Now a very large portion of the controversy in this case has been raised on those words which introduce the invention, 'and this part of my invention when working millstones with a blast of air,' I think you must give full force to the argument which has been adduced to me—a very forcible argument indeed—as to his describing in those words a particular mode in which he applies this particular invention of his. The defendants say you have described your invention to be—'Secondly, in exhausting the air from the cases of millstones combined with the application of a blast to the grinding surfaces'—they say, you have described it to be so; and, by the word 'blast,' you mean artificial blast, and we show that you mean artificial blast in this way, not only does the word 'blast' itself, with an ordinary signification, and independently of other portions of your patent, imply a blast which has been introduced by some artificial means, and not in the ordinary process of grinding, but we say further that that is completely established by looking to that disclaimed portion of your patent wherein there is reference to the disclaimed invention which you first thought you could lay claim to; but, finding you have been forestalled in that, you describe it this way, that 'the drawings show a combination of other parts of my invention, but this part of my invention may be applied to stones worked with a current of air obtained by a blast or exhaustion, or when worked without wind in the ordinary manner.' And, 'I may here remark that I am aware that it has before been tried to rotate the lower as well as the upper stones'—that is struck out. Now it is said here, and I think with great force undoubtedly, that if you had chosen in your invention to speak of three classes of things, and to classify the air passing through the stones to be in one way produced by air passing through the stones occasioned by blast,—another to be air passing through stones occasioned by exhaust,—another to be air passing through the stones when worked without wind in the ordinary manner; you thereby contra-distinguish the ordinary manner, the working without wind, from the mode of working with the blast; so that when we come to this part of your patent you say there that you work, as it is said by the defendant, in combination with the blast; you say there that you only do this (and of course that is the contest), you only apply this invention when you are working with an artificial blast of air. Now, let us see how far that can be just, as being the true interpretation of the second part of the invention."

Observe, the inquiry is not whether in the words "relates only to the plenum" a patentable invention has been described, but assuming that they do describe an invention, the discussion—omitting validity—proceeds at once to infringement.

"The contest is, that you claim for nothing, and do not desire to be considered as inventing anything, except in the case where there shall be an artificial blast of air. The words I have just read in the second part of the invention—I have not read the last part of all, which is ordinarily called the claiming part of the patent, in modern fashion—are, 'Secondly, in exhausting the dusty air when the same has been blown through the grinding surfaces of the millstones from the stone cases, or chambers receiving the meal as herein described.' The words there, 'blown through,' of course are larger than the word 'blast;' they have a wider meaning than the word 'blast,' even if you construe this patent according to the patentee's own language—certainly that portion of the case would not confine him to anything that involves simply the artificial blast of air if it stood there alone; but my reading of the patent is altogether different in this respect. I think he is telling you—and that is why I have taken the pains to go through the anterior state of manufacture—and I suppose him to have known, for the reasons I have given, as I suppose everybody to have known, when the invention took place, that there is a blast when working in the ordinary manner—the very word 'blast' is used by the defendant; and it is the only proper word that you could use for the air driving out in the ordinary mode, which carried off the dust and stive occasioned in the mill—that was greatly aggravated by what was done, and the plaintiff says he still thinks it most beneficial for working the mill to add to the wind which passes through the stones, in that manner, that artificial blast which will quicken the working, but at the same time increases this mischief which is complained of. Now, he says, I would introduce a process which will prevent the mischief occasioned by the stive passing through the stones; I apply it when I am working it to the cases in which I have introduced, by my own former patent, an artificial blast of air, that is to say, the second part of my invention when working millstones with a blast of air. What I do is this: "I introduce a pipe to exhaust or carry off." That *per se* would be no invention at all, because exhausts were known before. But he says, 'this part of my invention relates to sucking away the plenum of dusty air.' That is the very description of the invention; you do not get it until you get to this part of the case, as shown in Bovill v. Keyworth. That is the actual description of the thing invented—that is the regulated application of a thing known, as Mr. Williams very well put it in his able description of the case. He said, what you claim is not a new thing, because exhausts were known; but an application of an old thing to effect a given purpose which is a new purpose. I quite follow that, and quite adopt it. He says, 'This part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the millstones without a blast, this having before been practised as above mentioned.' Now, it was said in argument that this was no claim—it was in effect a disclaimer simply—a disclaimer to avoid conflicting with Newton's Patent; but this is certainly not the decision in Bovill v. Keyworth. The decision in Bovill v. Keyworth is—and I can find no invention at all until you get to this—the whole invention consisted in your just having that moderated amount of exhaust which would not draw through, because that is mischievous. The plaintiff has given his reasons, and I have heard no evidence to contradict that, and no reasons given, that Newton's plan was mistaken—in fact, it was never used; it had too great an exhaust; it had a bad effect in every way to draw the meal down the spout with the stive and hot air, and everything else that was mischievous; but the thing that I have invented is so adjusting my exhausting power that the plenum—on which I will say a word or two presently—of dusty air forced through the stones shall be removed and sucked away. Suppose, he says, I do it when I am using the blast, does that authorise anybody to do it at any other time? If a plenum of dusty air is produced, if there is pressure, as Mr. Gamman describes it, in the stone cases, and if that pressure can be beautifully adjusted, as it appears really to have been, on all the evidence before me; if it can be so adjusted as to get rid of all the inconveniences hitherto occasioned by just removing the plenum and nothing more, so that hitting that exact measure has prevented the escape of dust altogether—if that is done away with by the blast produced, which, for the previous reasons I have given, I hold is produced by the means which you can apply to the common operations—are you to be allowed to do that, because the plaintiff says that in using this invention he uses it with a blast? I apprehend not; because I apprehend the same principle that was acted upon in Bovill v. Keyworth—I quite agree, not in any way binding on this, of applying Lister v. Leather—must apply here, where the court said, supposing this patent to be all one combination, from first to last, we think then he claims part 1. and claims part 2. and claims part 3. You cannot take any one of those entire combinations of the three, supposing they were all three combined, if that portion be new, and upon that they followed Lister v. Leather, and Lister v. Leather, as it appears to me, is most completely applicable to this second clause in this, which is an independent claim altogether. Assuming, as I do, that the first clause has nothing to do with it, he tells you there is one particular independent mode of working to which I apply this my invention. I apply it in one particular way for a given purpose; but you cannot apply that, as my new invention, to do the identical thing with regard to something else, namely, the removal of the plenum, the very thing I wanted to do, because I have told you I am using it when I am using a blast. In other words, the plaintiff meant to say this—a blast is my great improvement; I think that the best way of working the mill; there was dust before, and there is more dust now, and therefore their blast became useless; but when I use my blast I use that which also exactly adjusts the drawing off by means of the exhaust with reference to the quantity of blast produced; and, that being done, the benefit is produced. This is my claim, and only that. I only claim the sucking away the plenum of dusty air. He has described that in his specification as a particular and given application of it; and certainly the rule in Foxwell v. Bostock has not the slightest application here, because everything is plainly declared and plainly indicated throughout this patent, that the blast is not new with reference to the former patent on this subject. The blast of air is not knew. In truth, it is scarcely a part of the combination, in real substance; but supposing it to be a part of the combination, the blast is not brought forward as new, but the removal of the plenum, plainly and distinctly; as he says, 'this part of my invention relates to that,' and he claims that and that only throughout the whole matter. Therefore he indicates distinctly what he claims; and, supposing you take this to be a combination of using the existing invention of the blast with drawing away the plenum, then you have no right to take that portion of the invention which will exactly effect the same thing, because you can apply it to another particular form of blast. I think, perhaps, a still stronger way of construing it, which would actually establish the plaintiff's right of standing upon this patent, would be to say, that a man is not supposed to be limited to the word 'combination.' He has used that word undoubtedly in the early part of it. 'Secondly, in exhausting the air combined with the application of the blast'—he is not to be so tied to the word 'combination,' when you find what he means in the second part is this—I do this, when I am using a blast, and my invention is that. I do use this with an artificial blast; but if you choose to use any common blast, you are not therefore to be allowed to take my invention.

"Then it was said, you have deceived the public, and that I take to be the point of Mr. Justice Willes' observation, who concurs with the Master of the Rolls, who came to the same view—that this was not limited to a claim to work with an artificial blast. I take that to be the meaning of Mr. Justice Willes' observation, that this gentleman has not disclaimed to use it with other blasts, because he has said, I use this particular invention with one particular kind of blast; you are no more entitled to use it with anything than produces blast that you would be entitled to take any other portion of a patent process, which is plainly and distinctly set out as the one that is claimed positively and distinctly as a new invention. Now, Mr. Justice Willes, in page 314 of the report of Bovill v.

Goodier, speaks upon this point. He says, 'I take upon myself to say that I humbly concur in the judgment of the Master of the Rolls in saying that this second part of the patent does apply to an exhaust, applied not only in conjunction with a superadded blast, but in conjunction with any blast at all, whether superadded or not; whether it is a blast caused by the action of the stones upon the air setting it whirling, subjecting it to the centrifugal force, the air entering through the eye of the stone, the exhaust drawing off the air which is introduced by such a blast as that. I see no reason for confining the word 'blast' in the specification to a superadded blast, and I find nothing in the specification to authorise me to express any doubt as to the propriety of that decision. Now, therefore, the patent is for the application of an exhaust, regulated in such a manner as to carry off—call it the plenum; I should call it the wind produced by the blast coming in; that is, an exhaust regulated according to the force of the blast used to go through the stone.' It appears to me that that which has been used to introduce so much confusion into this patent is this, that undoubtedly you may say, in this patentee's mind this was passing, as one of the best ways of using the invention as to the plenum—one of the best modes of using it is, in combination with the blast; because, according to his view, that produces the best effect of any, and he gives you the best effect of any; but at the same time it is not to be used with any blast, when he tells you, 'my invention relates only to sucking away the plenum of dusty air forced through the stones.' Therefore, if there is air forced through the stones, and a plenum occasioned by that air being forced through the stones, then he has claimed that, and invented that; and that cannot be invaded."

We see now that the limits of free inquiry as to a patent in the Court of Chancery are determined absolutely by what was done ten years previously in a court of law in a controversy of another nature between other people, to whom it was common ground that it was as simple and easy to cure by the application of exhausting apparatus the mischief resulting from forcing by a blast a plenum of air through millstones, as it is to regulate the draught of a fire by opening the damper in the flue. The examination by the Court of Chancery of the meaning of the specification was precluded, since the Court of Queen's Bench had said "the exhaust produced by the pipe and fan is to be proportioned to the plenum caused by the blast, taking care not to produce the inconvenient current of air against which a caution is given." What room was there after this for the Court of Chancery to inquire into the nature of the invention or the meaning of the specification? This, in fact, is the radical vice of the Court of Chancery in administering the patent law. The court professes that the validity of the patent is to be litigated unreservedly before it, but its practice is to inquire what a court of law did when the patent was before it, and then to torture and stretch the language of the specification so as to arrive at a conclusion in favour of the patentee, and therefore in apparent harmony with the decision of the court of law. The grammatical meaning of words, the very elementary rules of patent law, and the reputation of witnesses, are all unsparingly sacrificed to attain this result. We see that through the forgetfulness of Lord Campbell that the jury in Bovill v. Keyworth had not been asked any question as to the sufficiency of the specification, upon the ground that there was nothing new or peculiar in the manner of applying the exhaust. His misapprehension or at all events avoidance of the objection that there could not be a valid patent for the mere combination of any sort of exhaust with any sort of blast, and his dictum that the very kind and power of exhaust which was monopolised by the first claim in the second claim of this patent declared to be inconvenient and cautioned against, were all required to supply the appearance of a justification for the decision in Bovill v. Keyworth; but the commentary of Lord Campbell is the text of the Court of Chancery. To conform to that decision the Court of Chancery does not scruple to suggest that a "patentee is not to be bound by his own language," that possibly you need not "construe this patent according to the patentee's own language." It can "quite follow and quite adopt" the argument that this is not "a claim for a new thing, but an application of an old thing to effect a given purpose," and holds that "the actual description of the thing invented" is "the regulated application of a known thing," and yet can omit to say how the patent can be valid. The learned judge said that the principle that was acted upon in Bovill v. Keyworth was, he "quite agreed, not binding in any way" upon that court; but we shall see that in Bovill v. Smith he frankly said in summarising his judgment in Bovill v. Crate that he "was not at liberty to dispute" what had been determined in Bovill v. Keyworth. It is as true with respect to Lord Hatherley, when Vice-Chancellor, as we have ventured to say with respect to Lord Romilly, that the traditions and system of the Court of Chancery made it impossible for him rightly to discharge the functions of a jury and of the court of Common Law *in banco* in a litigation under a patent. We have seen that his lordship demonstrated that no invention was described in any words previous to those relating to the plenum, and avoided inquiring how, what was disclosed by these words could support a patent; and we shall see that he disposed of the unanswerable objection that the patent must be void for insufficiency of specification inasmuch as the statement that the invention relates to the plenum can by no possibility be an instruction how to do anything newly invented in reference to it, by saying "that sounds very well; but the answer is that the Court of Queen's Bench has decided that this is a new invention, and that it is sufficiently described." This indeed is the secret and key of the whole judgment in the present case, and of all the other judgments. It was decided to be a good patent in Bovill v. Keyworth. We have nothing to do but to enforce the rights there established, and find answers of some sort to the arguments and evidence submitted to us to displace those rights.

But we must continue our extracts from the judgment.

"I said before I closed my remarks upon the patent, I would refer to the case of Bovill v. Keyworth, which deals with several other points of importance in the case; but I at once say I read Bovill v. Keyworth as deciding no more than this. Bovill v. Keyworth mentions the application of the second branch of the invention with a blast; so that this question I have just been discussing certainly does not appear to me to have arisen in Bovill v. Keyworth. The principle may arise, whether you take part of the invention which is new, supposing it to be in combination; but that particular question did not arise there. When the Master of the Rolls says he takes Bovill v. Keyworth to have decided the validity of the patent in other respects, I take it to be perfectly clear that the Master of the Rolls is of opinion that the other points in the patent (say, for instance, the stive room) did not arise in Bovill v. Keyworth upon the question of infringement; but I read the Master of the Rolls' observation as applying to novelty, and in one sense you may say Bovill v. Keyworth is a decision on the patent on all its points as to novelty in this sense only; not that it arose in controversy, not that there was an express judgment upon it but, of course, it was open for the defendant, in Bovill v. Keyworth, to raise every point of novelty that has been raised before me here; and if he can show me that any one part of the patent is bad for want of novelty, although it had nothing to do with that part of the patent which he was adopting, yet if he could succeed on any one of those points it was open to him to do so. Therefore a decision in favour of the patentee leaves it open to any other persons to raise other questions of novelty by new evidence; but, as far as it went, it did satisfy the court upon the evidence before it—indeed, the verdict of the jury was taken on one particular point, which I must refer to presently as to Muir's patent. They had, at the time, no evidence against its novelty, and the court was satisfied of that.

"Now, the importance of Bovill v. Keyworth is this. It did determine an important point, which I confess was open to a great deal of argument, not indicating the slightest doubt as to the decision. I think it was a nice point, and a point requiring a great deal of argument, namely, whether or not there is any such thing described as was patented at all? There it was that the doctrine of Kay v. Marshall was brought in; because, on that part of the case, the decision was of very considerable importance. The defendants contended there (and I know Kay v. Marshall is cited in the argument, although the argument is given first, and the case mentioned afterwards), 'that, if the specification was not to be construed as confining the second claim to the millstone where the upper stone was fixed, that claim would extend to a combination of every practicable mode of applying a blast and every practicable mode of applying an exhaust to a mill, if any one of such modes of applying a blast be used, together with any one of applying an exhaust; and that so large and indefinite a claim to such numerous combinations was not a claim for a new manufacture which could be made the subject of a patent within the meaning of the Statute of Monopolies; and, also, that the specification had not particularly described any manner of performing the second part of the invention, and had not described the manner of performing every combination.' It is another form of Kay v. Marshall. Kay v. Marshall said, if the world has got the whole thing before it, you putting in your boundary line in the midst of that which is common property cannot mark you off any part of the common which the whole world has a right to feed upon; you cannot put a hedge across it and say, this is something of my own which I appropriate to myself. That cannot be done; and there is the double objection: first, you cannot do it; and, secondly, if you do attempt to do it, you have not laid a sufficient boundary line, which is taking the larger form, and taking all possible inventions—you have not laid down anything large enough to enable persons to work upon your patent. The court deals with the subject in that way, and again deals also with this (I read it because I shall not have to refer to it again), namely, whether or not the patent is sufficiently described as to the mode of operation, Now, Lord Campbell says this: 'The specification says,—'In carrying out the second part of my invention when working millstones with a blast of air, I introduce a a pipe to the millstone case from a fan or other exhausting machine, so as to carry off all the warm, dusty air blown through between the stones to a chamber as hereafter described.' 'And this part of my invention relates only to sucking away the plenum of dusty air forced through the stones, and not to employing a sufficient exhausting power to induce a current of air between the millstones without a blast.' That is the part

I have read before. Then he says—now, this is Lord Campbell's interpretation of the patent, and is, to my mind, of enormous importance to the plaintiff; and, as it appears to me, to all judges who have to consider fairly what the legal position of the plaintiff is—'The exhaust produced by the pipe and fan is to be proportioned to the plenum caused by the blast, taking care not to produce the inconvenient current of air, against which a caution is given.' Now, I have given my reasons for saying I include in 'blast' the blast that is produced by the centrifugal action of the stones; every word of that, of course, will apply to all questions raised, as to what it is, the plaintiff claims, and as to whether or not Kay v. Marshall could apply to that; and whether or not he has not given sufficient advice how the thing is to be done—that it is to be proportioned to a blast, taking care not to produce the inconvenient current of air as to which a caution is given, and he has given the proper mode of doing it. It is true he has described nothing but a fan and this exhaust—a well-known thing. But the learned judge says, 'How can a judge take upon himself to say that this may not be enough to enable a workman of competent skill to construct the machinery?' In other words, you are told to take the common machine, the well-known machinery fan, to construct the exhaust, and arrange it so as exactly to carry off the plenum which is caused, and not to produce the inconvenient current of air. Then Lord Campbell proceeds to say, and all the other judges concur in this judgment:—'According to the evidence, the specification was abundantly sufficient for this purpose; and therefore it could be no more necessary in the specification to explainn the details by which the pipe and fan were to be employed to create and regulate the exhaust than to describe how the millstone case or the stones themselves were to be fashioned. The learned counsel for the defendants, after being familiarly acquainted with the manner in which this part of the process is conducted, being asked to suggest the fit language to be employed to instruct the workmen how to adjust so as properly to suck away the plenum, that the stive may be discharged into the chamber above'—they seem to read that as Mr. Justice Willes does—'were unable to devise any improvement upon the specification.' Therefore, it seems to me to be clear that this gentleman has plainly told you what he claims. It seems to me Kay v. Marshall has really no application to the case—it is not an exhaust producing an inconvenient blast of air. It is an exhaust producing the effect desired. The combination is this. The plenum is required to be reduced in proportion to the quantity of blast that is introduced. This seems to be the combination, if any; and to say, as I said before, that, because he applies it to one particular case of such a blast being produced—supposing he uses those words which I rather think myself the whole construction of the patent would lead one to think they amount to—not only with regard to that, but he led others to believe that that was his particular mode of application—his mode of application would not deprive him of the benefit of the invention as settled by Bovill v. Keyworth to be the rule.

"As regards the justice of the decision in Bovill v. Keyworth, it is almost wrong in me to comment on that, after the long lapse of years that has taken place since the decision. With regard to the fact that it was an invaluable invention, I think nothing more is wanting than that we find that every one was setting to work to prevent this evil of dust and stive; and certainly we do find that after this invention—when it got to be known, when it came to be found of such utility—a flood of patents was being poured upon the public, both in France and England, up to that time—that seems to have been suddenly stayed; and it appears to have been because the right thing had been hit upon.

"That being so, probably I had better dispose of the other points on the patent itself. There are one or two points which I ought to notice. One is, that the first invention—namely, the invention of certain apparatuses for introducing air between the millstones—has been anticipated by Mr. Bovill himself in his own Scotch patent. Now, it would be a very extraordinary state of things if such a point could arise now, for the first time, after the eighteen or nineteen ordeals through which this gentleman has had to pass; but I think it is a sufficient answer to that to say this. In the first place, it would be a very strange thing, if he should have claimed exactly what he claimed only three years before in another patent. It is quite clear to my mind that he had no such notion; but that would not avail if there was one in the patent on which the public could act. I put this case in the same way as that which arose so often in Dobb's Patent in the case of Betts' invention. If you are to spell it out of this Scotch patent, I must have some evidence that somebody working on the Scotch patent could have spelt out the present invention from the Scotch patent. There was one set of holes introduced in the Scotch patent, a specific set of holes, a specific arrangement although there was some blunder in the framing of it. Some prepositions are introduced, and very oddly used, in the specification. In the first portion of his patent, 'by introducing a supply of air down the master line as many in number *in* the furrows,' instead of '*as* the the furrows,' or '*to* the furrows'—this is the specific course which is pointed out in this, and there is nothing of the kind pointed out in the Scotch patent; but what is relied on is this, that the holes may be made in any particular manner in the sides (I do not go through it for this purpose, but it comes near to that), and these may be made in either stone—*in either stone*—that is the part which is relied upon. Now here the invention is confined to a fixed top stone. They say there it may be in 'either' stone; then they say, you fall in with this description of the second patent, and it is anticipated by the Scotch patent. My answer to that would be, as far as I can see (of course I have no right to form my independent judgment without evidence), I can form no notion of any workman working this second patent by the description which is claimed in the first patent, and I have no evidence before me that he could. Therefore, I do not think that that was an anticipation of the plaintiff's invention."

With regard to the use made of the Scotch patent of 1846 it may be enough to say that under that patent Mr. Bovill secured the monopoly in Scotland of the blast into the closed eye, and the exhaust as an alternative means for ventilating the grinding surfaces, and in his specification stated that when exhaust was used instead of the blast, apertures might be made in any convenient part of either of the stones for the admission of air to the grinding surfaces; and it was contended that this was a clear anticipation of the first claim, which is for using exhaust to ventilate the grinding surfaces and providing ventilating pipes in the top stone when fixed—at all events, that "it could not be an invention patentable in 1849 to use the exhaust to ventilate the grinding surfaces, when the top millstone is fixed and provided with ventilating pipes, after this patent of 1846 for putting ventilating apertures in either stone when exhaust is used instead of blast." If it were decorous to laugh at anything falling from a learned judge, we should be disposed to entertain ourselves with the reasons by which this contention was refuted—"the improbability that the patentee would in 1849 patent in England what he had patented in 1846." But the patentee, beyond all controversy, did patent in England, six months after he had done so in Scotland, the very blast which was the chief subject of this patent! There are blunders in the wording of the Scotch patent, "so that no notion can be formed of any workman being able from it to perform the first clause of this patent." But the blunders referred to are not in the Scotch specification of 1846—they are in this present specification of 1849. They were fatal to the pretensions of the former, but are harmless to the latter! One weight and one measure! The liberties that may be taken with the language of a specification are unquestionably large when it is conceded that the patentee is not to be tied by it; but we doubt whether even Mr. Bovill's counsel ventured to ask the learned judge to indulge in such heroic flights as we have now to present.

"The other objection made is to the third part of the invention. I am not speaking of its novelty as to Fison's or others, or what was done at the Chelmsford and other mills. I did not hear Mr. Grove's reply upon that. The words are—'The third part of my invention consists in straining the air, which is surcharged with fine flour, through suitable porous fabrics, which retain the flour and allow the air to pass through; and this I accomplish by exhausting the air from the millstone case or other closed chamber receiving the meal from the stones, by means of a fan or other exhausting machinery, and blow the stive so exhausted into a chamber having its sides and top formed of one or more thicknesses of suitable porous fabrics, to allow the air under pressure to pass out deprived of the flour by means of this filtration. I also obtain the same result by placing the filtering chamber between the stone case or chamber receiving the meal and dust from the stones and the exhausting machine. The stive or dusty air is then sucked through the filtering fabrics instead of being blown through, and the air passes away clean as before.' Now, what is he describing there? He is not describing an invention of a fabric for filtering, because, if he was describing a combination of fabrics for filtering, it would not do, of course, for him to say, I take a suitable fabric; he must tell you what the fabric is; but the filtering process is part of the process in truth. This was not new; it was a process which was known before. But he says this: I am going to tell you now, having got rid of the stive out of the mill, how I will stop that stive when the air is on its way out, and catch it for you; and my process is, the mode of catching the stive—that is to say, where I will put the thing to catch it. All the world knows, solid matter may be separated from air by passing through porous fabrics; that is a process well known. I am not describing that; I am not about to teach you the best way of bolting, by means of pouring the stive through, but I am telling you this, and for that purpose I read the second as being very much combined with the third. I do not think the observation could be put in a much different form it I did not; but I rather incline to agree with Mr. Justice Willes and with Lord Campbell in saying that the third is the following up of the process in the second, because you cannot use the stive in the way the plaintiff is speaking of in his patent, until you have drawn it out in the manner described by one continuous sort of process. Having done that, you invent a plan to conduct it to a stive chamber, where all this can be easily achieved. Now, I apprehend, nobody could be impugned for taking any other process different from this of straining the flour and the air but, if his plan is adopted in the particular mode he has described, he says, 'any suitable fabrics.' Of course, if the objection could be used at all, there is foundation for considerable force in the objection in the evidence given by the plaintiff before the Privy Council, because he says there, it took him a long time to find the best fabric; but then his patent was not taken out for that. There are plenty of fabrics to do it; and he says I want any suitable fabric to comply with my patent, which patent is only for telling you how to conduct this stive on its road from the boxes to the chamber; so that you can sort it and send the air out. You may sort it in the way you think best; and some of them will sort it one way and some in another. There is some dispute on the evidence which is the best mode. He does not say, my patent is for a process for finding suitable fabrics for straining stive and air; but mine is a patent for finding you a process by which the stive taken out from the boxes can be saved, on its way, by the contrivance of a chamber into which I blow it, and the same fan which sucks it out of one will blow it out of the other; but it is not part of my business to tell you the best mode of sifting it. My process tells you that I do sift it, and also tells you the process by which I am enabled to sift it. In truth, these are all the objections standing on the patent, independently of the question of novelty as applied to this particular second claim. I have dealt with the question of novelty on the first claim, as being superseded by the Scotch patent. It was a little single point by itself. Then comes the great question of the novelty, and then comes the question of infringement.

It is possible that some may be found to attempt to comprehend the nature of the invention of Mr. Bovill, protected by the third claim of this specification as here expounded. We can only say, "Who would have suspected that that was the invention?"

The learned judge next proceeded to consider the evidence of anticipation of the invention adduced by the defendant.

"Now, the question of novelty is put in this way. It was said, at first we will not dispute your novelty if you will confine yourselves to the artificial blast and drawing off by the exhaust—we will allow your patent to be good, if you like, for that; but we say, if you talk of applying an exhaust to a common pair of millstones, so as to draw off the plenum, in that there is nothing new—that has been done over and over again. Accordingly, I have had to hear the evidence upon no less than thirteen different places where this has been said to have been done—not all the thirteen as to the claim, because two, I think, went to the stive room; but about eleven cases in which the process is said to have been adopted, beyond which there is a large quantity of French patents, and which were put before me, all of which were before the Master of the Rolls in Bovill v. Goodier except one, namely, that of Cabanes. Well, now, I dispensed with any reply on the bulk of those cases, because it appeared to me that there were only two cases which could seriously be brought into question. I will just say a word or two on the others, but I would rather deal in detail with those two. One of them, the Houghton Mills, seems extremely unimportant; but the other case, the case of the Iseleworth Mills, deserves considerable consideration. Now, as regards Mr. Muir's mills, I threw them out for this reason. I do consider Mr. Muir's mills as being totally and completely in evidence in the case of Bovill v. Keyworth, and the jury to have found upon it. The very same letter has been produced before me—a letter writen from Altona to the proprietor of Muir's mills at that time, with reference to a contrivance and a scheme and a drawing with reference to applying this exhaust, and so on. All that was used, and of course used with great effect, in the case of Bovill v. Keyworth, because it was a plan of blast and exhaust combined, exactly similar to what was supposed to be the point before the court in the case of Bovill v. Keyworth. The court afterwards refused to grant a new trial, and considered that, notwithstanding Mr. Muir's evidence, the jury correctly found in that case. I do not, therefore, think it right in me, some ten years afterwards, to suppose that I ought to give more credit to the witnesses who are now produced than to those who were then fresh, had the whole case before them, and had the full opportunity of discussing it. I pass Mr. Muir, therefore, on that ground. With regard to the minor ones, I will say a word or two on them presently."

We think it a public duty to call attention to the views here expressed as to the weight to be given to evidence; the more so as we shall find that very similar views have been enunciated by Lord Cairns, who, indeed, with that terseness for which he is justly celebrated, has reduced these views to a formula. It is to this effect: If a patent has once been the subject of trial by jury, and was held valid, on any subsequent trial the evidence offered by the defendant may be divided into two clauses; evidence that was submitted to the jury on the first trial, and having then been disregarded, is to be disregarded now; and evidence which though available on the first trial was not presented to the jury, and must have been considered unreliable, and must not therefore be acted upon now. The exhaustiveness and the thought and trouble saving character of this formula must strike everyone, but it is sadly out of keeping with the rules which are laid down for the guidance of juries in similar circumstances. A jury is solemnly reminded of its duty to consider for themselves the evidence presented to them and wholly to disregard the circumstance that a previous jury has had a similar question under consideration. Their duty is now to decide according to the evidence, and not to be a mere echo to repeat what a former jury may have decided.

We must not lose sight of the fact that, chiefly under the guidance of Lord Cairns, Parliament has deprived a person sued in Chancery upon a patent, of the right to submit the evidence of invalidity to a jury. It is of the highest importance, therefore, to scrutinise the manner in which the only tribunal open to him will deal with the evidence. It has dealt with evidence given by a gentleman of high character and position, having not the slightest personal interest in the result, supported by contemporaneous documents, and not even cross-examined, by saying, "How can we act upon his evidence when a jury did not do so ten years ago?"

(*To be continued.*)

## BRITISH ASSOCIATION.

### THE PRESIDENT'S ADDRESS IN SECTION B (CHEMICAL SCIENCE.)

The following is an abstract of the President's address in Section B (Chemical Science):—

Dr. Debus endeavoured to direct attention to the ideas which at present guide chemists in their researches—to place in a clear light the objects they are striving to attain, and to indicate the direction of the scientific thought of our time. To do this was by no means an easy task; for the more manifold and diversified the objects of science become, the more numerous and extensive its relations with other branches of knowledge, the more difficult it becomes to draw a picture of its actual condition. The speaker referred in the first place to the molecular arrangement of the atoms of which bodies are composed, and said that the views of chemists relative to the combinations of atoms in molecules, and to the methods of ascertaining this arrangement, have undergone great alterations and received great additions during the last 10 or 15 years. To a consideration of these changes he invited the attention of his audience. Eighteen years ago Professor Williamson read before the members of the association a remarkable paper which contained the germ of our modern chemical doctrines, and was the cause of many important discoveries. He proposed to regard three large classes of bodies—acids, bases, and salts—from the same point of view, and to compare their chemical properties with those of one single elected substance. For this term of comparison be chose water. The speaker proceeded to say:—Now, water is composed of of three atoms—two of hydrogen and one of oxygen. Williamson showed that all oxygen acids, all oxygen bases, and the salts resulting from a combination of the two, can, like water, be considered to be composed of three parts or radicals, two of the radicals playing the part of the hydrogen atoms in water, and the third that of the atom of oxygen. Potassic hydrate is water which has one of its atoms of hydrogen replaced by an atom of potassium, hydric nitrate is water which has one atom of hydrogen replaced by nitric oxide, and potassic nitrate is water with one of its hydrogen atoms replaced by nitric oxide and the other by potassium. This speculation, as every chemist knows, is well supported by experiments; it embraces three large classes of bodies which till then had been considered as distinct. Mr. Gerhardt, in 1853, extended Williamson's views by distinguishing two other types of molecular structure, represented respectively by hydrogen and ammonia; and succeeded, by help of the radical theory, in arranging the majority of the the then known substances under one or the other of the three types already mentioned. Like every theory which is in harmony with experience, the above considerations led to results of unexpected importance; for it soon became apparent that the radicals which thus replace hydrogen in water are not at all of the same chemical value. Dr. Debus then entered into an elaborate and technical explanation in proof of this statement, and went on to say:—Thus every year produces results which improve our conceptions of the atomic and molecular constitution of bodies; and as our knowledge improves new questions suggest themselves and our power over the elements increases. It has already become possible to prepare in the laboratory bodies of a very complex character, and which a few years ago only were found in the bodies of animals or plants. Alizarin, the beautiful compound of the madder root, has been obtained by artificial means in the course of the year by Messrs. Lieberman and Græbe. Results of such a nature render it highly probable that at no distant period it will be in our power to prepare artificially nearly all, if not all, the substances found in plants and animals. Here I must not be misunderstood. Organic structures, such as muscular fibre or the leaves of a tree, the science of chemistry is incapable of producing, but molecules, like those found in a leaf or in the stem of a tree, will, no doubt, one day be manufactured from their elements. I must not conclude this address without reference to two or three subjects of great importance. Professor Bunsen, of Heidelberg, has published a paper on the washing of precipitates. Every one acquainted with practical chemistry knows how much time is often lost in waiting for a liquid to pass through the filter. Bunsen found the rate of filtration nearly proportional to the difference between the pressures on the upper and lower surfaces of the liquid. If, accordingly, the funnel he fixed air-tight by means of a perforated cork to the neck of a bottle, and the air exhausted in the bottle, the liquid will run faster through the filter in proportion to the diminution of the pressure in the bottle. Comparative experiments, some made according to the old and others made according to the new method, showed that the filtration, washing, and drying of a precipitate, which took seven hours by the old plan, could be performed by filtration into an exhausted bottle in 13 minutes. But a saving of time is not the only advantage of the improved method of collecting and washing precipitates. A more perfect washing with less water than is required by the common way of proceeding is by no means the least recommendation of Bunsen's ingenious method. A very important paper has been published by Professor Leibig on the improvement of the nourishing qualities of bread. Certain quantities of phosphates and other salts form necessary ingredients of wholesome food. Now, it is well known that most of these salts which naturally exist in wheat remain in the husk. Liebig proposes to add salts, of a nature similar to those remaining in the husk, to the flour, and at the same time to substitute for the carbonic acid developed by fermentation, gas liberated from sodic carbonate. The bread prepared according to Liebig's recommendation is said to be of excellent quality, and to exceed in value bread made by the ordinary method. Mr. Graham, of her Majesty's Mint, has continued his researches in the absorption of hydrogen by palladium. Palladium appears to be able to absorb more than 900 times its volume of hydrogen, and to form a combination which consists of nearly equal equivalents of the two elements. Hydrogenium, as Mr. Graham calls the combined hydrogen, acts in this case like a metal, and thus the opinion held by some scientific men, that hydrogen constitutes the vapour of a metal, receives confirmation. The specific gravity of hydrogenium, as contained in the alloy, was found to be 1·95. These experiments are remarkable in more than one respect. The palladium which absorbs and combines with the hydrogen does not change its state of aggregation, but remains solid and expands as if it had been heated. The nodules of the palladium have consequently changed their relative positions and combined with hydrogen, while the continuity of the metal remained intact. The last subject to which I have to draw your attention is the beautiful paper by Professor Tyndall, on a new method of decomposing gaseous substances by means of light. Tyndall's experiments bring us face to face with the motions of atoms of molecules, and the relation of these motions to chemical decomposition. They will no doubt, at some future time, furnish valuable materials to chemical dynamics.

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## ON ROADS AND RAILWAYS IN NORTHERN INDIA, AS AFFECTED BY THE ABRADING AND TRANSPORTING POWER OF WATER

By Thomas Login, C.E.

At the last meeting of this Association I had the honour to draw attention to the "Abrading and Transporting Power of Water," when I ventured to bring forward my views regarding this important subject. Since that time I have studied the subject still more, and in the theory then brought forward I have been more and more confirmed. As many of those now present may not have seen or heard what these views are, I shall briefly recapitulate the most prominent points before entering on the question of their practical application to engineering works.

1. All silt-bearing streams when in train only transport a given proportion of earthy matter.

2. That the proportion depends on the velocity, and the nature of the materials transported.

3. Any increase to the velocity must cause a tendency to cutting, and any decrease to deposit.

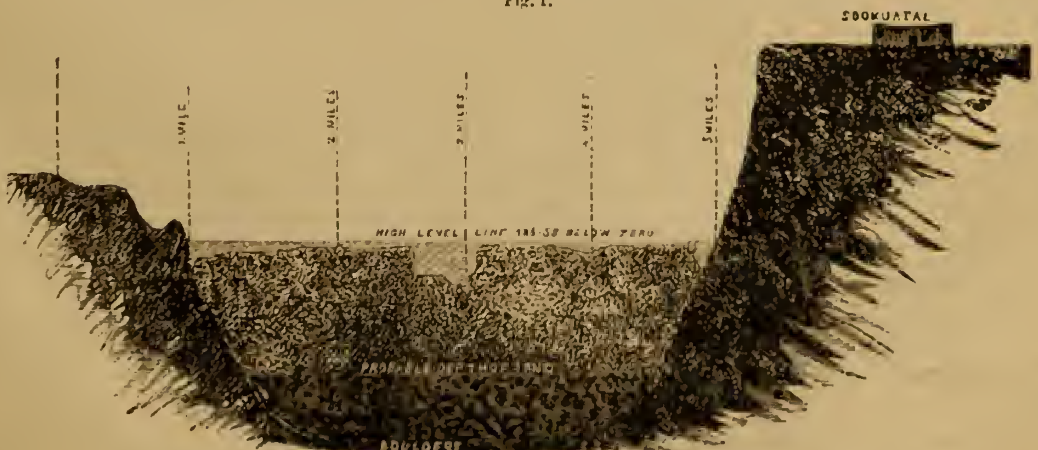
4. That a silt-bearing stream is retarded by having to exert a force sufficient to transport certain proportions of certain descriptions of earthly matter, consequently the slope required for a given velocity under such circumstances must be greater somewhat than if the water was pure.

From these conclusions I arrived at certain deductions regarding the flow of water down irrigation canals, which at present it is not necessary to dwell on, and went on to state that so far as my personal observations extended, that they went to show that, though the transporting power of water increased with the velocity, yet it diminished as the depth increased, and suggested that this was possibly owing to the rotatary motion of fluids, which are supposed to follow some figure more of the nature of the involute of circles rather than straight lines.

Having got so far, I stated my belief that it signified little what may be the cross section or velocity of a stream while passing over or through a work so long as it could again resume its natural section and velocity immediately on leaving it. The main object of my former paper was to show how the above-mentioned conclusions affected the question as to the proper velocity to give to artificial rivers, that is irrigation canals in India and elsewhere, and on the present occasion I propose confining my attention to the rivers of Northern India, with suggestions as to how they should be bridged. To do so, however probably it will be best to give a general description of the plains of Northern India without attempting to infringe on the work of the geologist, but simply to state what is now to be found, and what changes in nature have lately taken place and are at present being worked out. The plains of Northern India may be considered under two great divisions, namely, the Gangetic Valley and the Valley of the Indus. Approximately it may be said that from the head of the Bay of Bengal to where the Ganges escapes from the hills is a little short of 1,200 miles. The general shape of the surface of the country would in section be the quadrant of a very flat ellipse, with a small portion of both ends cut off.* The total fall fall, rather more than 1,000ft., commencing with rapid slopes near the hills, and ending with a fall of only one or two inches in the mile at the sea. These plains consist of alluvial deposits to unknown depths in alternate strata of clay and sand, but in addition to this are to be found extensive beds of limestone known in India by the name of "kunkur."

As a general rule, the uppermost stratum is a rich light clay from 5 to 10ft. in depth, with sand below it, and it is chiefly owing to this that Upper India is so very productive. Strata of clay, sand, and "kunker" are met with at various depths, and of various thicknesses, and all have a general parallelism to the surface, but how or when deposited the author will not attempt to discuss. These plains are cut up by deep troughs or valleys, usually from 5 to 10 miles broad, of various depths, from that of 10 to even 100ft. Fig. 1 is a section of one of them, and it is through these valleys that the large rivers that are fed by the melting of the snow

Fig. 1.



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* Possibly this curve may be parabolic.

now wander. These valleys are known in India by the name of "Khadirs," and as there is nothing similar to them that the author is aware of in England, it will be best to adhere to this local name in contradistinction to what is called Bhangir, or the high-level plain already referred to. The formation of these "Khadirs" is, however, a matter of interest to the engineer, so the author will state his views as to how he thinks they were scooped out and are being filled up again

In the great valley of the Delhra Doon, lying between the Ganges and the Jumna, and beyond the Sewalic range, where the ground chiefly consists of boulders and sand, with a covering of vegetable soil, there are evident marks to show that these two rivers stood at much higher level than at the present day. It is also self-evident that the sea extended several hundred miles further inland than the present head of the Bay of Bengal, so that at no very distant period, speaking in a geological sense of time, the chief rivers of Northern India must have had, when escaping from the hills, their beds higher than at present, and their channels shorter, so, with slopes more rapid, the transporting power of these rivers must have been much greater than now, and a violent cutting back on the bed has taken place from the sea, scooping out these deep troughs to excessive depths through the alluvial plains. This also would further add to the declivity of the beds of these rivers near the foot of the hills, and thus boulders could be transported for many miles further into the plains than they are at present. It is thus the author would account for only sand to great depths being found in the valleys of the large rivers some distance down their course, as, for example, on the Beas, where the Delhi Railway crosses it, also near the foot of the hills, shingle and boulders some twenty miles down the course of these rivers are to be found a few feet below the sand, as in the case of the Dadoopoor dam at the head of the Jumna Canal, where the foundations rest on shingle at a depth of about 10ft. below the bed. With sand overlaying boulders and shingle it can only be supposed that the beds of the rivers are here being raised, and as the Delta is extending year by year out into the Bay of Bengal, the river here also is becoming higher, so it is natural to suppose that all along the course of the river between these points a similar process is going on. This is a very important point to know, for though this silting up may be imperceptible, yet it clearly shows that there is no danger to any permanent work by a general depression of the beds of these rivers going on, as some suppose, so that any scooping out of the bed is only local, and can be met by local remedies. Borings, in the beds of torrents, which drain the southern slopes of the hills, and not the interior, and which meander over the plains rather than intersect them, give very different results to what are found in the valleys of the large rivers, as alternate strata of clay, sand, and kunkur are found.

It is necessary to know the rainfall at variont points to understand certain natural features, and the changes now going on. In the Gangetic valley the rainfall is considerable, being, on an average, nearly

20 inches a year at Delhi
30 " " Meerut
40 " " Roorkie

The level of the Bhangir here being so very much above that of the Khadir, a gradual wearing down of the Bhangir is going on, thus the high level plains between the Ganges and the Jumna, commonly called the Doab, is cut up by several large streams. With such a rainfall as there is all over the Doab, it is natural to suppose that there must be some line marking out the catchment basins of each stream, and that this line, by its being least exposed to the action of running water remains the highest, and is neither more nor less than the "back bone of the country," not caused by any upheaval, but simply that it worn down less than any other portion of the plains. It is along this ridge or ridges that irrigation canals should be led, but as the plains are so level, the general direction of these ridges is difficult to determine. This at once explains why so many cross sections of the country have to be taken to discover the best line for an irrigation canal and its branches, which are not necessary with a road or a railway where distance becomes so important an element.

The author would now make a few remarks on the valley of the Indus, that is, the plains which form the Doabs of the Punjab, which are similar geologically to those of the Gangetic valley, the only difference being that they have not any deep rivers intersecting the plains nor ridges similar to what is found in the North-western Provinces. Take, for example, the Richna Doab, the high level plains between the Ravee and the Chenab rivers, which is 50 miles broad near Lahore where the Bhaugir is only about 10ft. above the Khadir of the Ravee, and on the Chenab side at Wnzeerabad the difference of level is only 17ft., so that in a lateral direction there can be very little fall. Again the rainfall is very little compared with what there is in the valley of the Ganges, as approximately there is at Ilung 4in. yearly or one fifth of the fall at Delhi.

Cheeniot, 8 ... ... ... ... ... ¼ Meerut.
Sealkote, 30 ... ... ... ... ... ¾ Roorkie,

and these points are respectively about equidistant from the hills. The fact is that the land absorbs all the rain which falls, so that at fifty miles below the hills every vestige of drainage lines disappears. Not that no drainage passes over this line for it is on this parallel that the Lahore and Peshawur road runs, and 13,470 running feet of gaps, in addition to 37 bridges and culverts of various sizes are left in this embankment to pass off the cross drainage which comes down from the neighbouring country above where the rain is more plentiful, yet with all this waterway in a distance altogether of 59 miles (including the valley of the Ravee) in July, 1866, "the flood topped the road for over 8 miles in length, and made very extensive breaches, scouring out the site of road the embankment below the level of the country."

It appears to the author that in such a case it would perhaps have been better either to divert the drainage higher up, or to have had no raised road whatever, but to have allowed the flood to pass quietly off over the road. The effect in this case, by increasing the velocity at certain points, has been for the comparatively pure water which had harmlessly flowed through fields of cultivation to sweep away several miles more of the embankment, thus showing "that with increased velocity there must be abrasion." Where the floods even at higher velocities are not obstructed, no such action takes place, as the author in October, 1863, laid down a causeway of "kunkur" metal across the Khadir of the Sutledge at Loodianah level with the surface of the country, and up to 1867 it was standing, and for anything he knows to the contrary, it may be there still. Thus a number of floods have passed over it at great velocities, yet as the water had its proper load of silt there has been no cutting.

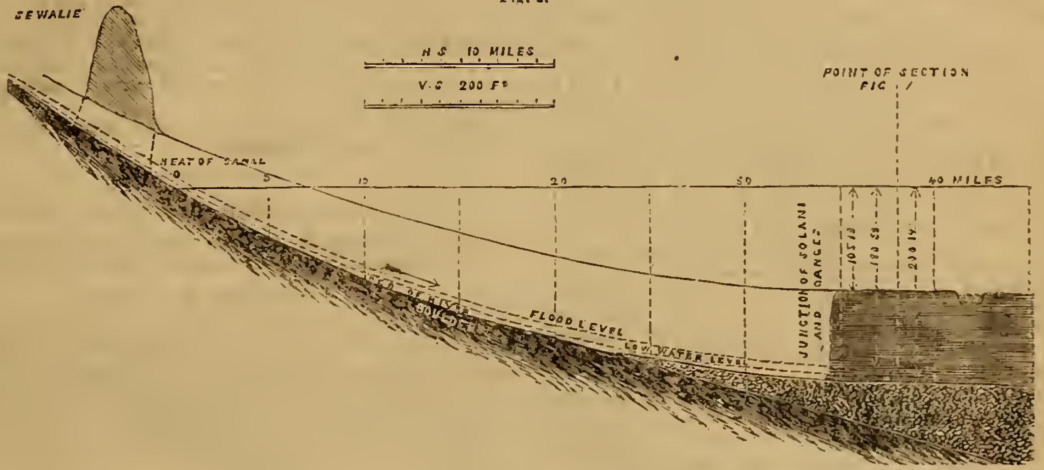
But to continue, the Richna Doab being so little raised above the Khadirs there could be no great fall east or west, consequently with a plain fifty miles broad with a considerable fall towards the sea, the tendency would be for the floods to spread themselves over it, and as the rainfall is so little, this drainage is ultimately absorbed. There is, therefore, no wearing down of this plain by the action of water, so instead of there being any natural ridges, the surface of the country is so uniform that the author found by one of his trial cross-sections, with points taken at every 400ft., in a distance of six miles in a straight line, that the highest point did not exceed in height the most depressed more than 3ft., though the fall of the country at right angles to this line was some 2ft. in the mile. It is this uniformity of the plain and the richness of the soil that makes the Richna Doab so peculiarly well adapted for irrigation, and in this opinion the author is supported by the late chief engineer of the Punjab, Lord Napier of Magdala.

The courses of rivers in India are very changeable, so much so that Government has to collect the land rents in the neighbourhood of these rivers on a different system to other parts so as to admit of change of proprietorship as the course of the river shifts. These deep troughs or valleys, called "khadirs," are the limits through which the rivers change their course from time to time, and though the course may be said to be always serpentine, the changes are not exactly so, but follow that of the valley; thus there is a gradual movement of all the bends downwards, so that after a given number of years, say half a century, the river may be exactly as it was fifty years before, but at the end of twenty-five years every bend would be formed at the opposite side of the valley. Sometimes the changes are more or less sudden, when instead of the channel moving gradually down, these bends are diverted, and the two ends get silted up, when these diverted channels often become a marsh; and are known by different names in different countries, such as "broads" in Norfolk, "lagoons" in America, "sheels" in Upper India, "dhars" in Bengal, and "chormgs" in Burmah. One remarkable feature of them is that they are on a lower level generally than the main river, proving that the rivers are raising their beds, but it is this peculiarity that makes it all the more necessary to guard against the tendency of the main steam returning to its deserted channels, and it is to this the author would more particularly call attention, for he believes that hereafter it may be a work of no little difficulty to prevent this where the large rivers are crossed by railways. During high floods a large body of inundation water passes down the valley, see Fig. 2, which is all more or less under water but its flow is retarded for various reasons, chiefly owing to vegetation, consequently, comparatively speaking, the water is pure and does not hold in suspension anything like the same proportion of earthy matter that the main stream does. To give sufficient waterway by flood openings to pass off all the inundation at its natural velocity would require exceedingly large bridges. To increase the velocity through the bridges implies a heading up of the water with a still greater reduction in the velocity on the up-stream side of the embankment, which necessitates a still further reduction of the silt held in suspension.

The water thus lightened of its load, rushes through the flood openings and reaches the down-stream side at an increased velocity, in nearly a pure state, and, as it must take up a proportion of earthy matter due to this velocity, a violent action takes place below the bridge, Nay, sometimes owing to this increased velocity on the up-stream side, a scooping out takes place above the bridge, and if the bridge happens to have a raised flooring, it simply becomes a submerged weir, doing harm instead of good by deranging the flow. If floorings are to be used they should be as inverts to rest the bridge on, and not raised to a higher level than the foundation. In nine cases out of ten it would be better to break up all raised floorings, and throw the material round the pier foundations, rather than give a plunging direction to the water down stream.

If this view be correct, it at once proves that with loose sand to unknown depths, the only safe mode for bridging the large rivers is to have deep foundations, which necessitate great spans, and iron girder bridges, and as the sand pump makes the sinking such a simple matter now, the difference of 10ft. more or less of depth in cost is insignificant. (In Madras, where there is an unlimited supply of heavy material, the case may be different and there shallow foundations may be more economical.) An extra depth of 10ft. or so, however, is nearly tantamount to doubling the sectional area of the waterway, and as water does not move in straight lines, it matters little what the shape of the section may be when passing through a bridge; thus the waterway may be doubled without adding to the breadth, but by deepening the bed. By this means, without adding much to the cost of a bridge, not only the main stream, but also the inundation water could all be passed through the one bridge, and thus a great saving effected by having no flood openings, and consequently no danger of the main river taking to these side openings, while the only inconvenience would be to cause the flood to last a few hours longer than it otherwise would. As, however, where the embankment crossing a valley is of a great length, all the water could not drain back to the main stream, after the flood had passed off, particularly as has been already shown, the ground is much lower away back from the river than at its banks. To get rid of this water, syphons with spoon-mouthed opening at both ends should be provided, so that though the water could rush through the greater length of the syphon at a velocity of even 10ft. a second, yet it would approach and leave the syphon at the natural velocity of perhaps not more that 2ft. a second. Thus no violent action could take place either above or below, and at the points of admission and egress, the water would have the proper level of silt due to its velocity.

Fig. 2.



From all the author has read, seen, or heard, he cannot help thinking that a large proportion of the late accidents on works in India is to be attributed to the causes assigned in this paper, namely, the excessive velocity given to a stream that has already been partially deprived of its natural load of earthy matter, thereby causing a violent action below, and sometimes even above bridge. The importance of the questions now raised as to bridging rivers in India is daily becoming greater, for, while this paper was being prepared, the Government of India has determined to construct the Lahore and Peshawur Railway, which line must cross, not only the Ravee, the Chenab, and the Jhilum, but also the Indus passing over the Richna Doab, which has above been described. Should, therefore, the suggestions now made be correct, it is evident that hundreds of thousands of pounds may be saved by adopting them, and thus, what is supposed to be one of the most difficult lines to construct in India may, after a proper knowledge of these laws is arrived at, enable the engineer to make this line of railway, and with perfect confidence of success, at possibly less cost than many of those now constructed. The author would only now add that the knowledge of the abrading and transporting power of water is not only desirable in designing roads, railways, or canals, but affects every question connected with hydraulic works in all countries. It would occupy too much time even to allude to them, but he may, however, venture to ask what would be the financial state of Southern India (which now does not pay) if harbours were constructed on sound principles, so as not to be silted up.

Time will not admit of the author describing a modification of these syphons, which he thinks, in some instances, may be introduced with economy for crossing minor streams, instead of bridging them in the usual manner; but he believes not only this can be done with advantage, but also, with spoon-mouthed syphons, inundation water in Bengal may be carried through embankments in regulated volumes, so as to be available for irrigation, thus adding both to the fertility of soil and the salubrity of the climate, while the embankments would protect the country from these devastating floods which so often destroy both life and property.

### Discussion on Mr. T. Login's Paper.

The President: This paper opens up a very large question, which I believe can hardly be fully discussed here as it deserves. The construction of the bridges in India has given a great deal of trouble, and I hope we shall have some discussion on this communication. (Hear, hear.)

Mr. Bateman: There can be no doubt of the importance of this question, in considering the great mischief done for want of proper consideration in leaving insufficient openings for the waterways of rivers. I can instance places in this very country—spots that are very well known. For instance, there is a case in the valley of the Clyde, close by Carstairs. I had occasion to investigate the question of floods in that river. I found them to be moderate floods, but no means existed, although the engineer of the railway had allowed three or four times as much in the way of bridge openings as he had ever allowed before in the course of a line, to allow the water to escape quick enough. In these large valleys in India it must be very difficult to give a sufficient amount of waterway in the same manner as it previously existed; for whilst it flowed all over the valley, the water comes down with less velocity, so that every impediment opposed to it is an absolute obstruction. You cannot pass the same volume of water through a contracted opening without its obtaining a higher velocity. The question will no doubt attract, more and more, the attention of railway engineers as they find themselves beaten by water. The question is one of wonderful interest, but it is too large a one, as the chairman justly says, for more than an incidental allusion to in this section.

Sir John Bowring: I certainly cannot go into any of these scientific questions that have been so ably discussed here; but as a traveller not unfamiliar with the Oriental lands, I am bound to bear testimony, my grateful testimony, to the immense service that has been rendered to the Oriental world by the attention that has been given to its interests—the great interests not only of the locality, and the great colonial interest of which we in England avail ourselves so largely, but really of the whole world. I cannot but contrast the condition of British India under British rule with its former condition, whether under the Hindoo or the Mussulman. I am quite certain that those unscientific races would never have been enabled to do what we have done, and what it is our bounden duty to do in the future, for in ruling that country we incur very great responsibility, and this responsibility certainly ought to lead to very active action. (Hear, hear.) We should not forget that in some of the mathematical sciences we owe a great deal to the Oriental. One advantage to this country is that they do recognise our superiority, and feel the value of our presence. I may say a word or two, founded on observations made when charged with important functions in some of those regions, in testimony of the thankfulness which I am sure will be reflected in the Indian mind for the services rendered.

Mr. Bateman: One point I forgot to mention is as to the gradual rising of the beds. Almost, as a rule, I think the beds of rivers do rise constantly and gradually. The question of the rising of the beds of the rivers is equal in importance as the openings of the bridges where you have to construct bridges across them, for you have to take that into consideration, and make future provision. I believe it is a universal belief that the beds of rivers do rise.

Mr. Vignoles, F.R.S.: My experience of rivers in different parts of the world quite confirms the great probability of the change in the direction of the rivers. A large bridge I built in Russia about twenty years ago, situated on the branch of a river, before we finished it seemed, in all probability, very likely to be left dry, and of the river assuming a new channel. No observation or report I could make to the Government would induce them to take timely measures to prevent that. Fortunately for the bridge and the Government, the accidental grounding of a barge at one of the upper points of the river created such an obstruction at the point where the deviation was likely to take place, that up to the present time the river continues in its old course. The latest accounts I have received, however, inform me that that cause is now removing, and unless some great remedial measures are taken, this grand bridge, which cost half a million of money, and which is half a mile long, is likely to be left without a river to span. What Mr. Bateman has referred to with reference to the Clyde, I had a similar case in the Brazils. We thought we had provided in every possible manner for the outfall of the water. But the water falling in those tropical countries in such enormous volumes, it came with such great velocity that it spread all over the plains, and the amount of waterway required fell beyond any probable calculation. It is the same in Spain. In many of the large rivers there the water comes down from the hills with such velocity that none of the channels are able to take it, and it spreads over a large surface. They have these bridges, but nothing will prevent the natural flow of the water, and the continual recurrence of the same accidents. Therefore, I for one felt very great interest in the paper, and I am exceedingly anxious that the attention of the Government should be called to the subject, with a view, if possible, of making some experiments, and laying down principles for the carrying out of those works which Mr. Login, from his experience, suggests. (Applause.)

Mr. Martin: I may mention the case of a large river in South Australia. For a great distance the banks on either side of the main river are very high, reaching 70 or 80 feet, and where the river runs close to these banks they are precipitous; but on the other side they shoal away, and the river runs in a circuitous manner through those banks. But, unfortunately, the river was not guided in its course by these high levels. The plain behind the river is lower than the margin of the river itself, and when the floods come down from the melting snow on the mountains, the water, instead of running down those natural channels, flows upwards, and overflows the banks at the lower part of the bend, falling into pools which are evidently portions of the old bed of the river. As to the inundation syphon, however well it may be designed for carrying the water off, I am afraid it must inevitably become choked when it returns, for I think the velocity is insufficient to keep the sand and silt in suspension.

Mr. Pole: I have nothing to add to the paper hardly, but, in corroboration of what Mr. Bateman said with reference to the rising of the beds of rivers, a remarkable instance occurs in the great river that traverses the plains of Lombardy. Owing to the great quantity of material brought down from the Alps, we find a similar condition of things, exactly the reverse of what we are accustomed to. Generally, when approaching a river we have to descend; there it is exactly the reverse. Not only the main river, but the side rivers are at a higher level than the adjoining land. The phenomenon is a very curious one, and gives rise to a great deal of trouble. The subject of the construction of bridges in India is very much too large to be discussed here with satisfaction. The observations of Mr. Login, I am sure are of great value, and will be prized by those who read them. (Loud cheers.)

Sir William Tite, M.P., F.R.S.: I can corroborate the last speaker with regard to what he has said concerning the plains of Lombardy, and there is another marked instance of the same thing in the case of the Po quite as curious. The river is reached by an ascent, and it runs high above the natural level of the land. It is, doubtless, due to the fact that the river carries with it a great amount of alluvial matter which accumulates, and makes not only the banks but the bed of the river to rise as it becomes loaded with this alluvial matter.

Mr. Bateman: I have hardly done justice to the alarming danger which hangs over the plains of Lombardy on account of the height of these rivers. There is every danger of the rivers bursting the banks and flowing into the lower ground, as is threatened in Holland. The Vistula is very much the same, and it may be seen in a very interesting manner in a gradual state of progress a little to the westward of the town of Marge, on the Lake of Neufchatel. There twenty or thirty little streams come from the mountains on either side, and little artificial embankments are made on either side by the deposit brought down. These little streams stand 5ft. or 6ft. above the level of the surrounding land, and the operation of the formation of the embankment may be watched every day.

Mr. Login: After the manner the paper has been received it is no use my saying much. Of course we all know rivers do rise in their beds, and the great question was whether there was a general depression. My theory is that they are rising, and that formerly these were lower and ran with greater velocity, so as to carry on boulders. If these deposits go on until the river is raised 50ft. or 60ft. the consequence is that the foundations of the bridges must be sunk through the deposit. With reference to the question Mr. Bateman asked me, we must have embankments crossing rivers of that kind; but on the Punjaub, where we have very level lines, and floods only lasting about twelve hours in the whole year, the question is, is it not proper to allow the small flood of, perhaps, 18in. or 1ft. to pass over the rails. I contend that the flood would leave the line just as it found it, because the water would pass over the line without doing it any injury, the only inconvenience being that it would, perhaps, stop the traffic for about twelve hours a year. The saving would be very great, for we should be able to construct a line for about half the price; and therefore I say, hundreds of thousands of pounds may be saved by my plan. It has been tried on twenty-five miles of the Scinde Railway with perfect success. The water passed over the line with no increase of velocity, for the moment you increase the velocity the water will make a cutting, whatever the embankment may be.

The President: I proposed that we pass a vote of thanks to the author of this valuable paper. (Applause.)

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## THE RESISTANCE OF ARMOUR PLATES.

### On the Penetration of Armour Plates with Long Shells having Large Bursting Charges, fired obliquely.

By Joseph Whitworth.

At the meeting of the British Association at Norwich last year, I contributed a paper to the Mechanical Section "On the Proper Form of Projectiles for Penetration through Water." This paper was illustrated by diagrams showing the effects proper on an iron plate, immersed in a tank of water by projectiles with flat-hemispherical, and pointed heads. In that paper I claimed for the flat-fronted form of projectiles made of any metal three points of superiority over the Palliser projectiles adopted in the service.

1. Its power of penetrating armour plates even when striking at extreme angles.
2. Its large internal capacity as a shell.
3. Its capability of passing undeflected through water and penetrating armour below the water line.

This latter feature was, I think, satisfactorily proved by the experiments described last year, and I now desire to draw the attention of the section to the experiments I have made for illustrating the penetrative power of long projectiles with the flat front, fired at extreme angles against iron-plates.

These experiments are illustrated by the projectiles actually fired, and the plates they penetrated, which are laid on table.

The gun from which all the projectiles are fired, is called 3-pounder, though capable of firing much heavier projectiles; it weighs 315 lb. and the maximum diameter of its bore is 1.85. The charge of powder used in all cases was 10 oz., and the weight of the 6 diameter projectiles is 6 lb

No. 1 is a portion of a plate 2 in. thick, penetrated by the 6 diameter flat-fronted projectile, at an angle of 35°.

No 2 is a similar piece of plate 1.7 in. thick, completely traversed at an angle of 45° by the flat-fronted projectile No. 2, which buried itself to a depth of 30 in. in a backing of iron borings.

No. 3 is a piece of plate 1.75 in. thick, penetrated at an angle of 65° by the flat-fronted projectile No. 3.

No. 4 is a plate 1.7 in. thick nearly penetrated at an angle of 45° by the flat-fronted projectile No. 4.

No 5 is a plate 1½ in. thick, against which the *pointed* projectile No. 5 was fired at an angle of 45°. The projectile failed to penetrate the plate, being deflected by the pointed form of end; the distortion of its shape shows the force with which it struck the plate, and proves the excellent quality of the material which could resist such a test.

No. 6 is a plate also 1½ in. thick, against which a Palliser projectile 2¼ diameters long made of Pontypool iron with the *pointed* form of head has been fired; the projectile has scooped out a furrow 4 in. long and 7-10 in. deep. It broke up into fragments, of which 48 were recovered. The plates, No. 1 and 3, were purposely thicker than the projectiles could quite pass through, in order that the "work" of the projectiles might be as severe as possible; an examination of the projectiles themselves will show how well they have withstood the severe strain to which they have been subjected. The data thus obtained fully establish, I think, the superiority I claimed for the flat-fronted projectiles made of my metal, and satisfactorily prove:

1. That the flat-fronted form is capable of piercing armour plates at extreme angles.

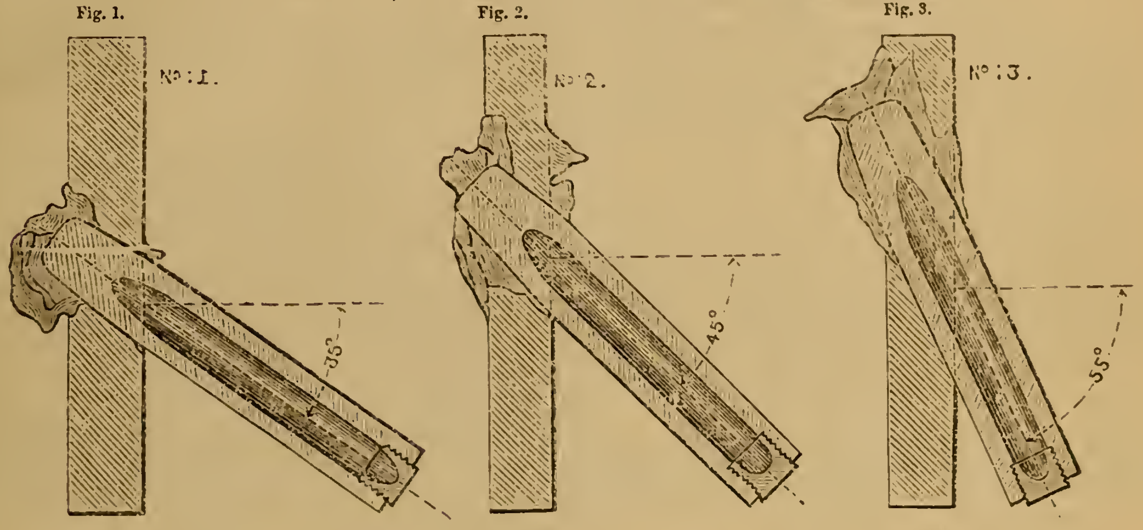
2. That the quality of the material of the shell enables their length to be increased without any risk of their breaking up on impact, and thus increases their capacity as shells.

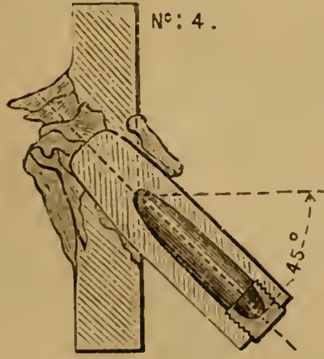
3. That this increase in length, while adding to the efficiency of the projectile as a shell, in no way diminishes but increases its penetrative power.

4. That the amount of rotation I have adopted in my system is sufficient to insure the long projectile striking "end on," and thus to accumulate the whole effect of the mass on the reduced area of the flat front.

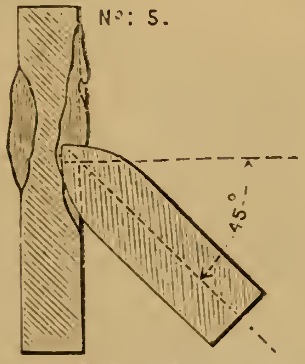
These experiments show, further, that the Palliser projectiles fail to penetrate when striking at an angle, solely on account of the form of the head; the Whitworth projectile, which resisted the shot, and did not break up, being deflected in precisely the same manner as the Palliser projectile which was shivered into fragments.

FLAT-HEADED SHELLS, SIX DIAMETERS LONG, CONTAINING BURSTING CHARGES





FLAT-HEADED SHORT SHELL.



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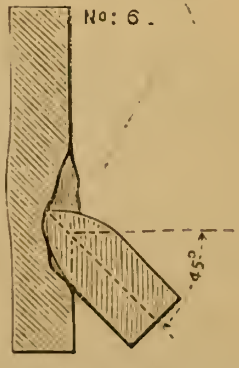

POINTED SOLID SHOT.

The objections I made in my paper last year to the Palliser projectile—1st, that its form of head causes it to glance off, and, 2nd, that the brittleness of its material causes it to break up on impact—I have now proved to this section. The facts illustrated by these experiments are not of recent discovery: ever since 1858 I have experimented upon and advocated the flat front: I have on the table a small plate ½ in. thick experimented upon in 1862 with hardened steel bullets fired from my small-bore rifle. No. 39 is the hole made by a flat-fronted bullet, which has penetrated the plate at an angle of 45°. No. 40 is the indent of a hemispherical-headed, and No. 41 of an ordinary round-nosed bullet, both fired at the same angle of 45°; these three rounds were fired in 1862.

Within the last few days I have had a Palliser-shaped bullet fired on the same plate at the same angle, in order to compare the effect produced on a larger scale on plate No. 6. It is interesting to observe how closely the effects obtained with the small calibre of the rifle agree with those of the 3-pounder gun, which form the subject of this paper. These experiments were made with a gun of small calibre from considerations of economy and convenience, but I always found that what I could do with the smaller calibres of my system could be reproduced in the larger sizes, and from my past experience I feel warranted in asserting that the effects of penetration now exhibited could be repeated on a proportional scale with my 9 in. guns at Shoeburyness, or 11 in. guns my firm are now engaged in constructing.

A glance at the formidable nature of the projectiles thrown by these guns, and a consideration of the effects they may be expected to produce, will show the importance attaching to the question of penetration of plates by long projectiles. The 9 in. guns, to which I have referred, weigh 15 tons each, and are capable of firing powder charges of 50 lb. A 9 in. shell five diameters long weighs 535 lb., and will contain a bursting charge of 25 lb. I have no hesitation in saying that these projectiles would pierce the plated side of a ship, at a distance of 2,000 yards, and at some depth below the water-line. The 11 in. guns will weigh 27 tons each, and will be capable of firing 90 lb. powder charges. The 11 in. shell five diameters long will weigh 965 lb., and will contain bursting charges of 45 lb., and would pierce the side of the ship Hercules plated with 9 in. armour at a distance of 2,000 yards. Were it not that the increased destructiveness of war must tend to shorten its duration, and diminish its frequency, thus saving human life, the invention of such projectiles could hardly be justified; but believing in the pacific influences of the most powerful means of defence, I have named these long projectiles the "Anti-war" shell.

The principle I have always insisted upon, and laid down for my guidance in artillery experiments, when either a low trajectory or penetration is required, is "that every gun should be capable of withstanding the largest charge of powder that can be profitably consumed in its bore."

I have drawn up a table of the sizes of the bores of my guns, with their proportionate powder charges, and can undertake that they shall be fully equal to this duty, and realise the highest possible consumption for a given quantity of powder. But the guns adopted in our naval service are not equal to such a test, nor, as I believe, are they proportioned as to realise the best effect from the quantity of powder they consume.

Four guns of 12 in. bore have lately been put on board the Monarch, they weigh 25 tons each, and fire charges of from 57 lb, to 67 lb., and projectiles of 600 lb. weight.

I have no doubt that these guns have been made with all possible care, and are as strong as their material and construction admit of their being; but if the weight of these guns was in proportion to the capacity of their bore, and the material was the best that our metallurgical skill could supply for such a purpose, they ought to fire 117 lb. of powder, and projectiles of 1,250 lb. weight. These would then be indeed efficient weapons, but at present they are more formidable in name than in reality. We are often flattered by being told that we have the best guns in the world; that may or may not be the case; but I think we should not rest contented while we are still so far from having attained all that our present advancement in mechanical and metallurgical science has rendered possible to us.

PARTICULARS OF AMMUNITION FOR WHITWORTH GUNS, FROM 5·5in. TO 13in. BORE.

| | | Common Shells, Cast Iron 3·5 Diameters Long. | | Armour Shells, Whitworth Metal, 5 Diameters Long. | |
|---|---|---|---|---|---|
| Calibre of Bore. | Powder Charge. | Bursting Charge. | Weight of Shell. | Bursting Charge. | Weight of Shell. |
| in. | lb. | lb. | lb. | lb. | lb. |
| 5·5 | 11·0 | 4·0 | 70 | 6·0 | 120 |
| 7·0 | 23·0 | 8·5 | 150 | 12·0 | 255 |
| 8·0 | 34·0 | 13.0 | 220 | 18·0 | 375 |
| 9·0 | 50·0 | 18·0 | 320 | 25·0 | 535 |
| 10·0 | 70·0 | 24·0 | 440 | 35·0 | 740 |
| 11·0 | 90·0 | 32·0 | 580 | 45·0 | 965 |
| 12·0 | 117·0 | 40·0 | 750 | 58·0 | 1250 |
| 13·0 | 150·0 | 51·0 | 960 | 75·0 | 1615 |

Mr. Whitworth's patent cartridge increases the range from 15 t0 20 per cent.

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## THE RESISTANCE OF VESSELS.

FIRST REPORT. PREPARED FOR THE COMMITTEE BY MR. C. W. MERRIFIELD.

The subject referred to us is a very large one; and having regard both to the space which a complete report on such a matter would require, and to the time at our disposal for making it, we have thought it best to lay before the present meeting a first report, in which we confine ourselves to the resistance which ships offer to propulsion, and to their behaviour in respect of rolling. These are, in their several directions, the preliminary subjects to the inquiry committed to us; and they are also the parts of naval science on which exact experiment appears to be most urgently needed, both for the direct knowledge of these branches, and also as a foundation for experiments on propulsion and the other applications which depend upon them. Knowledge of the work to be done should precede the selection of the tool with which it is to be performed.

### RESISTANCE.—TOTAL RESISTANCE.

The question of resistance may be treated in two ways—either in gross, as regarding the power to drive a vessel of certain form and dimensions at a specified rate; or, in detail, as regarding the exact way in which the vessel and the propeller act and re-act upon the water which they disturb. Hitherto there has been but little connection established between the phenomena of detail and the general result, the former not being understood with any reasonable degree of certainty, and the latter also being far from settled with precision.

The variable elements which go to make the resistance what it is are chiefly velocity, form, condition of surface, and absolute dimension. The effect of form is as varied as the number of forms which can be given to a floating body. As regards dimension, assuming the forms to be geometrically the same, it has been found that vessels of different absolute size do not correspond in the degree of resistance which they encounter, whether in smooth water or in waves. It will also be seen that the absolute length of a ship, considered irrespectively of breadth or depth, has a direct influence on the resistance.

As regards velocity, it is usual to assume, in books on hydrodynamics, that the resistance of water varies as the square of the speed. For the purposes of naval architecture, this can only be taken to be roughly true under certain limiting conditions, beyond which the law of the squares deviates widely from the observed facts. It appears to be probable that this increase, as the square of the speed, is rather a minimum than a general rule of increase, and that such a minimum is only attained by ships of good form and of a length which is a certain function of the speed. The vague words, "Good Form," are used designedly, it being still uncertain what the best form may be and what extent of deviation from it takes the vessel out of its operation. When the vessel is shorter than a certain limit of length depending on the velocity, the resistance seems to increase more rapidly than the square, and the power needed to drive the ship consequently increases faster than the cube of the velocity.

It may save confusion to remark that the measure of resistance is referred to a unit of distance, while power is referred to a unit of time. For any law of resistance, therefore, the power varies as the product of the resistance and speed, and where the velocity varies, we have simply to use the corresponding integral formula.

As already remarked, the leading formulæ of the resistance of water are

$$R \propto V^2, \ H\,P \propto R\,V \propto V^3,$$

the latter being the strictly necessary consequence of the former. There is but little disagreement among writers up to this point. But the moment we attempt either to assign values to the constants of the equations which they imply, or to introduce the corrections depending on the complex phenomena, which always, more or less, mask the mere question of fluid resistance, we find very little agreement.

The chief elements of the resistance of water to a body moving through it are—

1. The direct head resistance due to the work of thrusting the water to the right or left, with or without vertical motion, in order to make way for the body to pass.

2. The skin resistance or friction of the water on the surface of the moving body, combined with the effect of surface eddies and other minute phenomena.

3. The back pressure, due to the diminished pressure in rear of the moving body, and in wake of any corners or unfairness of surface which may cause eddies.

4. In addition to these, there are the phenomena of capillarity and of the viscosity of water. These are of importance as regards minute bodies, including even small models. But for large ships they are sufficiently accounted for in the arbitrary constant of skin resistance. This fourth head may therefore be neglected, except when we wish to pass from ships to models.

For extreme shapes it does not appear that the three leading elements of resistance can be grouped under one term. But there is reason to believe that for vessels of a certain form they all involve, with a respectable degree of approximation, the square of the velocity, and also that the forms, for which this is true, are among those which offer, *cæteris paribus*, the least resistance. Under these circumstances, the formulæ depending on skin resistance may be made to include the other two by merely altering the constants. We conjecture that, when authors state that certain elements of the resistance may practically be neglected, they usually mean that they can be accounted for in assigning the values to the arbitrary constants, which in any case must be determined from experiment. We have named vessels of a certain form; this form must be regarded as still unknown, except with reference to some limitations of a negative character, even these being rather indefinite. They include a fine entrance and a fine run, and an absolute length of not less than the length of the trochoidal wave moving with the same velocity. The actual determination of the form of least resistance is not only unsolved, but the data of the problem are yet unknown.

The first formulæ that occur are the well-known co-efficients of steamship performance:—

$$\frac{\text{Speed}^3 \times (\text{displacement})^{\frac{2}{3}}}{\text{Indicated horse power.}}.$$

$$\frac{(\text{Speed})^3 \times \text{area of midship section}}{\text{Indicated horse power}}.$$

As affording a rough measure of comparison, the tabulation of these formulæ for different ships is extremely convenient. But they are of very little assistance in settling a theory. Even for the same vessel, tried under apparently similar conditions, these co-efficients do not appear to be constant quantities. Moreover, the varying efficiency of the steam engine and of the propeller, considered as machines for the transmission of power, are inseparably grouped with the work of overcoming resistance. When the consumption of coal is substituted for the I.H.P., the efficiency of the furnace and boiler also comes in. Some of these remarks apply to Mr. Hawksley's approximate formula:—

$$\text{Velocity in statute miles} = 27 \left( \frac{\text{effective horse power}}{\text{wetted surface in } \square'} \right)^{\frac{1}{3}}.$$

But this was only intended for rough purposes.

We may here mention a formula given by Mr. Greene in a paper read at the Franklin Institute of New York, and reprinted in the *Mechanics' Magazine* for 8th July, 1864. It proceeds on the assumption that the power expended in overcoming back pressure and friction in the engine varies directly as the speed—

$$\text{H. P.} = D^{\frac{2}{3}}\,V\,(\cdot 1552 + \cdot 0046846\,V^2),$$

the constants being obtained empirically.

Most modern formulæ for resistance take account of the form of the vessel in such a manner as to require the use of the drawings of the exterior surface of the ship. The Swede, Chapman, in his well-known treatise on shipbuilding, assumes that the surface of the vessel may be divided into small portions, the resistance of each of which will be proportional to its area, to the sine squared of the inclination, and to the square of the velocity, with a certain small correction on account of the currents which are set up by the ship's own motion, and which modify the pressures. But he himself saw reason from subsequent experiments to doubt whether the law of the sine squared, or even that of the velocity squared, was applicable to the forms which he used.

Euler[*] and most of the older writers use the sine squared of the inclination, as the factor representing the effect of obliquity; and this theory has been revived by Mr. Hawksley in a discussion at the Institution of Civil Engineers, reported in their proceedings for 1856, vol. xvi., page 356. But we think that there is now ample experimental ground for believing that, whether or not this law be true with respect to an infinitesimal portion of a plane receiving the impact of a thin jet of water, it is not true either of plane surfaces of considerable extent, or, as a differential formula, of curved surfaces. It evidently fails to take account of the effect of the stream which is set up along the surface in deflecting the impact of water on the part of the surface further back from the entrance. The assumption that this has no effect is not one which can be admitted without proof; and the experimental evidence tends the other way. Chapman's later experiments, and the experiments of the French Academy and those of Colonel Beanfoy,[†] are all against the hypothesis of the sine squared of the inclination. The supposition that the sine squared of the inclination represents the effect of the obliquity of the after-body is still more open to doubt than when it is applied to the fore-body.

As a contribution to the history of the subject, the following translation from a tract of M. Dupny de Lôme will be interesting:—

Romme, in his memoir for the Academy of Sciences, in 1784, while giving an account of the experiments made by him at Rochefort on models of ships, one which represented a 74, and again in his work on the *Art de la Marine*, had very succinctly laid down that this resistance was independent of form. "Provided," he went on to say, "the water-lines have a regular, fair curvature, as is the case in modern vessels, the greater or less fulness of the bow or stern neither increases nor diminishes the resistance of the water to their progress."

In direct contradiction to this too summary rule, which has long obstructed the progress of naval architecture, my experience leads to five principles, which I state as follows:—

1°. Among vessels of similar geometrical form, of different size, but all having their immersed surface exceedingly smooth, and driven at the same speed, the pressure needed to attain this speed increases more slowly than the surface of the greatest transverse section. It is near the truth to say that, for similar forms, the resistance per square metre of midship section, at the same speed, decreases as the vessel increases, in the ratio of the square roots of the radii of curvature of its lines, these radii being themselves proportional to the linear dimensions of the ships; it is therefore wrong to compare the resistance of different ships by means of experiments made on models to reduced scales.[‡]

2°. If the same vessel be driven at different speeds, the force needed to obtain these velocities increases less rapidly than the square of the speed, while that is small. The force increases as the square for ordinary rates of 3 to 5 metres per second, according to the condition of the surface in respect of smoothness. Beyond that speed, it increases faster than the square.[§]

3°. The diminution of the angle of entrance, and the lengthening of the radius of curvature of the lines which the water has to follow, especially in the replacement in wake of the stern by the water coming up from below, are the principal means of diminishing the resistance. This has the greater influence, the greater the driving power. For very slow motion, the influence of form is less than that of surface friction.

4°. The sharpness of the bow, both above and below the water line, which has in calm weather the effect just mentioned, has more marked advantages in a heavy sea-way.

5°. The smoothness of the wetted surface plays a considerable part in the resistance; and this part, due to friction, varies but little with the speed.

I add that the resistance of the hull increases markedly in narrow channels, and still more where the depth of water does not much exceed the draught of the ship, so that experiments ought to be made in deep water.

Finally, my numerous observations on the resistance of ships in calm weather and open sea agree, with a close approach to exactness, with the following formula, which I have since adopted as the measure of resistance:—

$$R = K\,S\,(V^2 + 0{\cdot}145\,V^3) + K^1\,S^1\,\sqrt[3]{V}.$$

In this formula, I call—

S, the area of midship section in square inches.

$S^1$, the product of the mean girth (wetted), into the extreme length, also in square metres.

V, the speed in metres per second.

K, a co-efficient varying with the form, diminishing inversely as the square root of the radii of curvature of the longitudinal sections, and also diminishing with the mean angle of entrance. This second reduction amounts to about 15 per cent., as the mean angle of entrance comes down from 45° to 15°. It is, therefore, about one-half per cent. for each degree between those limits.

$K^1$, a co-efficient independent of the form, and varying only with the smoothness of the wet skin. This co-efficient can increase in the ratio of 1 to 10, from 0·3 for bottoms very smoothly covered with good copper, and the heads of the nails well beaten down, to 3·0 for hulls covered with weed and barnacles.

R is the resistance expressed in kilogrammes, and corresponding to the speed V.

For each ship experimented upon, two trials are sufficient to determine K and $K^1$.

For the Napoléon, while clean, the copper being oxidised, not greased, I found

$$K = 1{\cdot}96 \qquad K^1 = 0{\cdot}44$$

from which I obtain for the general expression for the resistance to the passage of the ship through the water.

$$R = 1{\cdot}96\,S\,(V^2 + 0{\cdot}145\,V^3) + 0{\cdot}440\,S^1\,\sqrt[3]{V}.$$

A table previously given shows that during the trial trip of the Napoléon, the values of S and $S^1$ were—

S between 990 and 1000 square metres.
$S^1$ between 1580 and 1610 square metres.

* * * * *

The power needed to obtain this speed is obtained from this calculation by multiplying the resistance, so calculated, by the velocity.

The above remarks are translated from a Memoir published by M. Dupny de Lôme on the occasion of his candidateship for the French Academy in 1865–66. It is reprinted in M. Flachat's "Navigation à Vapeur Transocéanienne," vol. i., p. 206.

It may not be out of place to mention, in explanation of M. Dupuy de Lome's remarks about the angle of entrance, that the architects of the Imperial Navy avoid the use of the hollow bow. There is at most a slight concavity at the forefoot. Hence the angle of entrance has a meaning which is sometimes lost in modern English practice.

M. Bonrgois, in his Memoir[*] on the Resistance of Water, gives formulæ which may be grouped under the general form of

$$R = B^2 V^2 \left(K_1 + K_2 \frac{l\,V^2}{B^2} + K_3 \frac{S}{B^2\,V}\right)$$

$B^2$ being the area of midship section, S the wet surface, and $l$ the breadth extreme. $K_1$, $K_2$, and $K_3$ are constants which vary with different classes of vessels.

The dependance of the resistance of ships upon the theory of waves appears to have been first insisted upon by Mr. Scott Russell. That gentleman seems to have been the first to discover that there was a relation between the length of the ship and the velocity of advantageous propulsion, this relation being taken directly from the theories of the solitary and of the trochoidal waves. We will state his theory of resistance in as few words as possible.

### *Scott Russell's Theory of the Form of Least Resistance.*

A vessel may be divided longitudinally into three portions—bow, straight middle body (if any), and after body. The midship section may be of any shape whatever, the resistance due to it depending on its area and wet girth only. The fore body must have for its level sections curves of sines (harmonic curves) whose equation may be written as

$$x = \frac{l\,\theta}{\pi},\ y = \tfrac{1}{2}\,b\,(1 + \cos.\,\theta),$$

$b$ being the half breadth of the ship at any level, and $l$ the length of the fore body, which must not be less than the length of the "solitary wave," which has the same speed as the ship is intended to have, in order that the resistance may be the least possible. The after body is to have trochoids for its level lines, their equation being

$$x = \frac{l^1\,\theta}{\pi} + \tfrac{1}{2}\,b\sin\theta,\ y = \tfrac{1}{2}\,b\,(1 + \cos.\,\theta),$$

$l^1$ being the length of the after body, which is not to be less than that of one-half of the oscillating or trochoidal wave of the same speed as the ship. The straight middle body may be of any length whatever, as it will only affect the resistance by increasing the surface for friction; or, subject to these conditions the resistance of the ship will be expressed by

$$(K \oplus + K^1 S)\,V^2,$$

where $\oplus$ represents the area of midship section, and S the wetted surface. K and $K^1$ are co-efficients, the former of which may be roughly stated at one-tenth of that due to a flat plate drawn flatwise through the water, and the latter depending upon the condition of the surface. For a pure wedge bow, whose angle is $\epsilon$, Mr. Scott Russell considers that the resistance varies as

$$\left(\frac{\pi}{2\,\pi - \epsilon}\right)^2$$

$\epsilon$ lying between the limits of 12° and 144°; and where the bow is compounded of this and of the wave form, he gives, as a rough measure of the resistance, a formula obtained by compounding this, in such proportion as may properly represent the geometrical combination of form, with the resistance due to the wave form.

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[*] See his "Scientia Navalis" (St. Petersburgh, 1749), vol. i., page 213. See also D'Alembert, "Traité de l'Equilibre et du Mouvement des Fluides. Ed. of 1770, page 225.

[†] See Chapman (by Inman), page 257; Bossuet, "Hydrodynamique," vol. ii., page [illegible]; Beaufoy, page 87. See also Scott Russell's "Naval Architecture," page 168; or "Proceedings of Civil Engineers," vol. xxiii., page 346, as to the French experiments.

[‡] M. Reech, Director of the Ecole d'Agriculture du Génie Maritime, has long since pointed out in his lectures the error frequently made of comparing the resistance of vessels of various forms by means of experiments upon models driven at the speed proper to the vessels themselves. (Note by the French author).

[§] I am here speaking of vessels only partially immersed, not of vessels which are entirely under water. (Note by the French author).

[*] Published at Paris, by Arthur Bertrand, s.d. See also Sonnet, "Dictionnaire des Mathématiques Appliquées," Art. "Résistance des Fluides,"

As far as can be judged by Mr. Scott Russell's published writings, there appears to be some unsettled ground in his theory relatively to the shape of the after body. The form of the bow is simply that of one-half the profile of a solitary wave of translation, laid horizontally instead of vertically. The form of the stern is also taken from the form of the wave, which is set up when a hollow in the surface of the water has to be filled up; but it is nowhere made clear whether this form ought to be given to the level sections, or to the vertical longitudinal sections, or whether some compromise should be made between the two; and it seems probable that the author himself was doubtful on the subject. The experiments recently made under the direction of the Committee of the British Association appointed to make experiments on the difference between the resistance of water to floating and immersed bodies (Report for 1866, p. 148), seem to indicate that that doubt is still unsettled.

Without hazarding an opinion as to whether this form is really that of least resistance, it appears certain that the curves used are among those along which fluid particles can glide smoothly, without causing supernumerary diverging waves in the liquid.

The general formula for the length of a ship given by this theory is—

$$\text{Fore body in feet} = \frac{2\,\pi}{g}\,V^2 \text{ in feet per second.}$$

$$\text{After body} = \tfrac{2}{3} \text{ fore body.}$$

The following are the values of the factor and its logarithm. which give the length of the fore body in feet, when the velocity is given in—

| | | |
|---|---|---|
| Feet per second | 0·19,518 | log. = 9·29045 |
| Knots per hour | 0·55,610 | log. = 9·74515 |
| Statute miles per hour | 0·41,985 | log. = 9·62310 |

Professor Rankine states, as the result of his own observations, that it is possible to shorten the bow to two-thirds of the length given by this formula, without materially increasing the resistance, but that it is very disadvantageous to shorten the after body.

In the "Proceedings of the Civil Engineers," vol. xxiii. (for 1864), p. 321, is a paper by Mr. G. H. Phipps, on the "Resistance of Bodies passing through the Water." Mr. Phipps considers that the total resistance may be subdivided as follows into additive parts—

Head resistance—varying directly as the midship section, and inversely as the square of the projection ratio of the bow.

Stern resistance—a similar function for the stern.

Friction resistance—varying directly as the surface immersed.

Additional head resistance—an empirical correction assumed to be a function of the immersed surface, and of the draught of water.

The sum of these resistances is then multiplied by the square of the velocity.

The paper was followed by a discussion, in which most of the leading English writers on Fluid Resistance took part. The paper and discussion thus constitute a very fair *résumé* of the opinions then held on the subject in this country.

Mr. Phipps considers that the co-efficient of friction of water on the outer surface of a vessel is less than on the inner surface of a pipe; and this is, to a certain extent, in accordance with the experiments of Darcy on the friction of water in pipes, which led to the conclusion that the co-efficient of friction consists of two terms—one constant, and the other varying inversely as the diameter of the pipe.

Mr. John J. Thornycroft, C.E., in a paper read before the Institution of Naval Architects this year, and which will appear in their forthcoming volume of "Transactions," gives the following formula, the form of which is derived from experiments on the flow of water in pipes:—

$$\text{I. H. P.} = V\,h\left\{S\,f\,\frac{3\,n}{2\,n + l}\,V^{1\cdot7} + \phi\,\text{S.C.}\,\frac{n^{\frac{1}{8}} + 3}{l^{\frac{1}{8}} + 3}\,V^{2\cdot7}.\right\}$$

Where S = the wetted surface,
V = the velocity in knots,
$l$ = length.

$$h, f, n, \text{C are constants empirically determined}\begin{cases}\log.\ h = \overline{3}\cdot65450\\ \log.\ f = \overline{2}\cdot10170\\ \log.\ C = \overline{2}\cdot0041\\ n = \overline{3}80\end{cases}$$

$$\phi\,S = f\,(\sin\theta)^{2\cdot5}\,d\,s.$$

$d\,s$ representing an elementary portion of the surface S, and $\theta$ the angle which this portion of the surface makes with the line of motion. It will be noticed that the formula involves a large number of constants, more or less arbitrarily determined.

Professor Rankine, in a paper in the "Transactions of the Institution of Naval Architects for 1864 (the substance of which is repeated in a treatise on "Shipbuilding: Theoretical and Practical"), states that the processes amongst the particles of water through which resistances to the ship's motion may be caused indirectly, may be thus enumerated:—

1. The distortion of the particles of water.
2. The production of currents.
3. The production of waves.
4. The production of frictional eddies.

The first cause he regards as having no appreciable effect on actual ships, although possibly sensible in small models. Of the second cause (the production of currents), Professor Rankine remarks that it "never acts upon a well-designed ship, for such a ship is so designed that the particles of water glide over her surface throughout its whole length, and are left behind her with no more motion than such as is unavoidably impressed upon them through adhesion and stiffness; and hence the failure of the earlier theories of the resistance of ships which were founded on experiments made with flat plates, wedges, and blocks of unfair shapes.

Dr. Rankine then gives a detailed account of the waves which accompany a vessel driven at a speed greater than the limit to which she is properly adapted, showing that they diverge from the course of the vessels, at an angle depending on the proportion in which their speed of advance is less than her speed, and thus carry off energy, which is lost; and he proceeds to state:—"The conclusion to be drawn from these principles is that for each vessel there is a certain limit of speed, below which the resistance due to the production of waves is insensible, and that as soon as that limit is exceeded that resistance begins to act, and increases at a very rapid rate with the excess of speed." "Through the discoveries of Mr. Scott Russell, a vessel can be designed in which this kind of resistance shall be insensible up to a given limit of speed, and therefore the resistance due to waves has no sensible action on a well-formed ship." These remarks, of course, apply only to waves formed by the ship, and not to sea waves which she may have to encounter.

"The resistance due to frictional eddies thus remains alone to be considered. That resistance is a combination of the direct and indirect effects of the adhesion between the skin of the ship and the particles of water which glide over it; which adhesion, together with the stiffness of the water, occasions the productions of a small whirls or eddies, in the layer of water immediately adjoining the ship's surface." Instead of assuming that the frictional resistance is simply proportional to the actual immersed surface, Dr. Rankine uses what he calls the augmented surface, which is obtained by multiplying each infinitesimal element of the surface by the cube of the ratio which the velocity of the gliding of the water over that portion bears to the speed of the ship, and summing them. Let $s$ be the actual surface, and $q$ the velocity-ratio of gliding; then the augmented surface is $\int q^3\,d\,s$; and if, further, V be the speed, $g$, gravity, $w$, the heaviness of water, and $f$ the co-efficient of friction, then

$$\text{Eddy resistance} = V^4 f\,\frac{w}{2\,g}\int q^3\,d\,s.$$

Taking the cubic foot as the unit $\frac{w}{2\,g}$ does not differ much from unity for sea water, and the formula thus reduces to $V^2 f\int q^3\,d\,s$.

It is, of course, impossible to calculate $\int q^3\,d\,s$ in detail for every ship, and it therefore becomes necessary to find some auxiliary formula. In the "Philosophical Transactions" for 1863, pp. 134-7, Mr. Rankine has shown that the augmented surface of a trochoidal riband on a given base and of given breadth may be found by multiplying their product by the following co-efficient of augmentation—

$$1 + 4\,(\sin\phi)^2 + (\sin\phi)^4$$

in which $\phi$ is the angle which the inflexional tangent makes with the base. For a ship in which the stream-lines or tracks of the particles of water are trochoids it would be a sufficient approximation to integrate—

$$\text{length} \times \tfrac{1}{2}\text{ breadth} \times \left\{1 + 4\,(\sin\phi)^2 + (\sin\phi)^4\right\}$$

with regard to the draught of the water, considering both the angle $\phi$ and the half-breadths as variable elements to be determined from the drawings. Where the stream-lines are not trochoids, $\phi$ may be taken as the angle of greatest obliquity. But the theory has been only partially extended to three dimensions; and indeed, if it were possible to do so, the mere introduction of a third variable would not meet the case, unless account were taken of the vertical displacement of the surface of the water, consequent upon the uniformity of pressure at that surface.

The resistance determined by the calculation of the augmented surface includes in one quantity both the direct adhesive action of the water on the ship's skin, and the indirect action through increase of the pressure at the bow and diminution of the pressure at the stern.

For the coefficient of friction, Professor Rankine takes $f$ = 0·0036 for surfaces of clean painted iron. This is the constant part of the expression deduced by Professor Weisbach from experiments on the flow of water in pipes. The corresponding coefficient deduced from Darcy's experiments is 0·004.

The augmented surface in square feet, multiplied by the cube of the speed in knots, and divided by the I.H.P., gives Rankine's coefficient of propulsion. In good clean iron vessels, this ranges about 20,000; while in H. M. yacht *Victoria and Albert* (copper sheathed), it reached 21,800. Its falling much below 20,000 is considered to indicate that there is some fault either in the ship, or in her engines or propeller; or else that the vessel is driven at a speed for which she is not adapted.

Professor Rankine adds, that "as for misshapen and ill-proportioned vessels, there does not exist any theory capable of giving their resistance by previous computation."

This again raises the question: What are good forms? According to Professor Rankine's theory, they are forms along which a particle of water can glide smoothly. Among these, as a particular case, Mr. Scott Russell's wave-lines appear to be included. But these are by no means the only ones which satisfy the problem of smooth gliding, or of stream-lines. Another method of constructing curves fulfilling this condition has been given by Dr. Rankine in a series of papers published respectively in the "Philosophical Transactions" for 1863, p. 369, and in the "Philosophical Magazine," for October, 1864, and January, 1865. Elementary descriptions of this method are given in the *Engi-*

*neer*, of the 16th October, 1868. and in a treatise on "Shipbuilding, Theoretical and Practical." Their theory has not yet been carried very far, and when we have reference to three dimensions, it does not appear that any specific mathematical form is to be preferred in respect of its total resistance to a long, fine, fair ship, either drawn or modelled by eye, by a practised draughtsman or modeller.

A possible connection between the resistance of ships and their depths of immersion has been pointed out by Pr. Rankine in some papers published in the "Proceedings of the Royal Society" for 1868, p. 344; in the "Reports of the British Association" for 1868; in the "Transactions of the Institution of Naval Architects" for 1868; and in the *Engineer* of the 28th August and 30th October, 1868. He shows from theory, corroborated by his own observations, and by those of Mr. John Inglis, jun., that every ship is accompanied by waves, whose velocity of advance is $\sqrt{g\,k}$, $g$ being gravity, and $k$ the mean depth of immersion, found by dividing the displacement by the area of water-section. So long as the speed does not exceed $\sqrt{g\,k}$, these waves cannot produce any additional resistance; but when the speed exceeds that limit, the waves are made to diverge from the ship at the angle whose cosine is $\frac{\sqrt{g\,k}}{\text{speed}}$, and thus to carry away energy, like the other diverging waves previously mentioned.

The form of the midship section does not appear to exert any influence on the resistance to propulsion in still water, except so far as it affects the extent of wetted surface exposed to the action of the water. If the wet girth and the breadth at the water-line be given, the form of greatest area will be a segment of a circle; but this will not be the solution of the question which usually presents itself, namely, given the breadth and the draught required, the form for which the ratio of area to surface shall be the greatest possible. In the particular case in which the draught is half the breadth, it is easily seen that the ratio of area to girth is the same for a semicircular as for a rectangular section, and, therefore, that the solution lies between these extreme cases. It does not appear that the general problem has yet been solved, and perhaps, as the really practical problem relates to the ship and not to the midship section, it is of secondary interest. A restricted solution has been given by Mr. James Robert Napier in a paper read before the Glasgow Philosophical Society, and reprinted in the "Mechanics' Magazine" for 24th April, 1863, vol. ix., page 311, and in the *Engineer* for 1st May, 1863, vol. xv., page 245.

The best ratio for good propulsion of length to breadth and draught, even when it is assumed that the length exceeds Scott Russell's limits, is not yet known This is not perhaps of practical importance, inasmuch as considerations of economy, capacity, and handiness generally settle these proportions, without much reference to a theoretical maximum of efficient propulsion, But the extent to which an increase of breadth or depth, leaving other things unaltered, affects the propulsion itself, can hardly be regarded as within our settled knowledge.

The resistance of the air to a ship's hull is not a point to be neglected in practice or in experiment, but it is not one which we propose to discuss here.

The above contains an abstract of nearly all that is known concerning the total resistance of a ship in smooth and deep water. We do not consider it necessary in this report to enter into the question of the increased resistance due to shallow water, narrow channels, or a rough sea. We may sum up the result in the broad statement that there exists no generally recognised theory or rule for calculating the resistance of a ship. Many such rules have been put forth, but they do not agree in their form or in their result, and the credit of each consequently rests, as a practical matter, on the reputation of its author.

### Resistance Considered in Detail.

It cannot be said that our knowledge of the detailed phenomena, which accompany the motion of a floating body through the water, extends far below the surface of the liquid. Meanwhile, the following things appear to be known.

For any vessel driven through the water by any power which does not re-act on the fluid, there must be a certain movement of the surrounding liquid, chiefly in the direction of the vessel's motion, which shall be sufficient to absorb the work done by the propelling force; for this is really nothing else than the work done by the power in overcoming the resistance. Much of this is masked by oscillatory movement. Now the setting up of an oscillation involves an expenditure of work; but the maintenance of the oscillation, once established, is independent of the force which caused it, to just the same extent that it takes work to set a pendulum swinging, but once set going, the continuance does not depend on the starting force. It follows that making a wave takes up propelling work; but that a wave once started maintains itself or dies out, as the case may be, independently of the propeller, which it can only effect by getting in its way.

In a vessel of good form thrust through a fluid, we first meet with a head pressure which relieves itself by the formation of a head swell, which disperses itself all round if time be allowed for it, either by the sharpness of the vessel's entrance, or by a slow rate of advance. This fixes a limit of speed, which cannot be advantageously exceeded, dependent on the length of entrance as well as on its form—on the length alone, if the form fulfil certain conditions. If the vessel be pushed beyond the speed of dispersion of this wave, it has to be pushed up hill, at a loss of useful work.

The frictional resistance of the surface of the ship also carries a stream of water in the sense of the ship's motion. In fact, nearly the whole work of friction is expended on producing this stream, which forms a part of the ship's wake.

The necessity of filling up the vacuum, which would otherwise be left in rear of the ship, also produces a following stream, accompanied with waves.

In vessels driven at a speed beyond what is suited to their form and dimensions, there are also supernumerary waves, an account of which will be found in Professor Rankine's writings, already referred to.

In vessels of unfair form there will further be violent eddies or whirlpools. as well as extra waves. Seeing that it takes an expenditure of work to make these, it is clear that least resistance means least disturbance. In reality, very little is known about these eddies. Their surface action has been observed, and may easily be seen in dirty water, with froth especially; but their extent in depth, and their amplitude as the depth increases, are utterly unknown; and the other phenomena are not sufficiently well understood to admit of the effect of these being got at by exhaustion, that is to say, by being equated to the unexplained residue from the effects of the other known causes. Very little, again, is known about the direction in which the replacement aft takes place. The water, may of course, pour in either laterally or from behind, or it may well up from underneath as a wave. More or less, it probably does all three, and the proportion in which it does each is among the things which neither experiment or theory has as yet revealed.

Theoretically it is of no importance whether we consider the ship in motion and the water at rest, or the ship at rest and the water in motion in an opposite direction. Practically the conditions are modified by the consideration that a stream of water almost always has a sloping surface, in which case a resolved part of gravity is one of the active forces* Besides this, streams useful for experiment are restricted in depth and width, and the conditions of narrow and shallow channels introduce foreign considerations of a very complicated character.

(*To be continued*).

## MANCHESTER STEAM USERS' ASSOCIATION.

### GOVERNMENT ACTION WITH REGARD TO BOILER EXPLOSIONS.

By Mr. Lavington E. Fletcher, C.E.

We make no apology for again recurring to this important subject, as the increasing number of victims annually sacrificed is, we feel sure, sufficiently appalling to command the serious attention of scientific men, with a view to lessening, if not altogether preventing such a fearful loss of life. The following suggestions prepared for the British Association by Mr. L. E. Fletcher are, we think, well worthy of attention :—

It is not in accordance with the Rules of the British Association, for Reports presented by Committees appointed to investigate and report on certain subjects, to be discussed in the meetings of the Sections. There are circumstances however at the present time that render it especially important that the opinion of the members of the British Association should be fully expressed on many of the questions touched on in the report just read relative to Coroners' Inquests and Steam Boiler Explosions. The Home Secretary stated in his place in the House of Commons very recently that he would do his utmost in the recess to prepare a measure for the suppression of steam boiler explosions, so that it is of great importance that suggestions from all parties should be invited on this subject, and that all the various plans proposed should be fully considered, so that the whole question may be well sifted. Under these circumstances I have under the advice of one of the Secretaries of the British Association, prepared a brief secondary paper, on which it will be in order to raise a discussion. After the report already presented to the Association relative to Coroners' Inquests and Boiler Explosions by the Committee appointed to undertake that duty, I need do nothing more in this paper than name the points on which it is desired to obtain the views of the members of the Mechanical Section of the British Association.

The constant recurrence of boiler explosions, and the number of lives annually sacrificed therefrom, has aroused public attention to this subject. The public begin to suspect that these disasters are not so accidental as it has for a number of years been attempted to make out, but that they might, after all, be prevented. The system of periodical boiler inspection has proved itself sufficient to accomplish this task, and therefore the public naturally ask,—why do not all steam users have their boilers inspected, and if they neglect this simple precaution, which has now been adopted by so many for the last fourteen years, why should not the law step in and compel them to adopt it?

This, therefore opens the first question, whether it is expedient or not for the Government to interfere in the matter of the prevention of steam boiler explosions, and if so, in the second place, what would be the best mode in which Government action should be taken. In answer to this second inquiry, there are at least three plans now before the public, of which a brief outline may be given.

One of these plans is that the Government should take the supervision of every boiler in the country, with the exception of locomotive and marine, and through the medium of the Board of Trade should test all new boilers, and periodically examine them when set to work, as well as all others already in use, the examinations being made both when the boilers are at rest, as well as when at work with steam up.

All Englishmen have a strong dread of Government interference, and of the introduction into this country of the continental paternal system, fearing lest it should hamper progress and fetter individual action. This measure therefore is one which, to say the least of it, is calculated to provoke considerable opposition.

Another plan is, to render inspection compulsory, but not that the Government should take the task of examining boilers in its own hands, that is to say, it is proposed that no steam user should be allowed to work a boiler that had not been examined and certified as safe by some local inspection association or insurance company, duly authorised by the Government as competent to the task.

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* This remark is due to Bourgois. See his Memoir, sup. cit. p. 3.

This plan has certainly less of the air of the continental paternal system about it, and appears more adapted to the usages of this country, though it by no means appears to be free from difficulty in its application. It is important that the integrity of the inspections should be preserved, and it may be well to suggest for consideration, whether there might not be a difficulty in securing this if the question of deciding on the safety of all the boilers in the country was handed over to a number of competing joint stock companies. Joint stock companies clearly exist for the sake of dividends, and it is difficult to see, if they are to be paid by steam users for granting certificates for the safety of boilers how the integrity of those certificates could be secured under a pressure of competition for business. Judges, to be impartial, should not be remunerated by those whose cases they have to adjudicate, more especially if their payment depends on giving satisfaction. It is feared that under such a system, inspections might grow lax, and that the sale of certificates would soon be not unlike the sale of indulgences in days gone by. It is therefore a point for discussion how far it would be wise to commit the safety of all the boilers in the country to the charge of commercial competing companies intrusted with the monopoly of the sale of boiler certificates. Possibly there may be some way of meeting this difficulty, but it was thought well to throw it out for discussion on the present occasion.

A third plan is that every steam user should be left perfectly free to lay down what description of boiler he may think best, and to enrol it or not, either with a Boiler Inspection Association or Boiler Insurance Company as he sees fit, and, indeed, that he should be free to do just what he likes as long as he does not burst his boiler, but in the event of explosion it is proposed that the Government should then step in, make a most searching investigation of the facts, and publish the information for the benefit of the community at large. On this system the steam user would be left perfectly free in his choice of means, but would be held responsible for results, and, in the event of explosion, would be open to a claim for damages from the relatives of those killed by the failure of his boiler. This plan, it is argued, would act preventively, inasmuch as it would it is hoped, arouse to suitable vigilance all those connected with the use of steam which is all that is required for the prevention of steam boiler explosions.

These are three of the principal plans now before the public. The first proposes to act on the paternal system, and to take every boiler under the Government wing. The second does not propose that the Government should undertake inspections itself, but that it should leave them to duly authorised local associations, rendering it, however, compulsory that the steam user should avail himself of one or the other of these organisations. The third plan goes on the principle of believing every man innocent till he is proved guilty, and of punishing offenders on the hope that by so doing a repetition of the offence by others will be prevented.

Such is a brief recapitulation, and but little more, of the measures now before the public, while the few suggestions that have been added to this brief recapitulation have been thrown out more to stimulate discussion than by way of advocacy in the case of either plan, and full discussion is now invited on these questions from the members of the Mechanical Section of the British Association.

(Signed) Lavington E. Fletcher.

41, Corporation-street,
Manchester, August 17th, 1869.

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## REPORT OF THE COMMITTEE APPOINTED TO CONSIDER AND REPORT HOW FAR CORONERS' INQUISITIONS ARE SATISFACTORY TRIBUNALS FOR THE INVESTIGATION OF BOILER EXPLOSIONS, AND HOW THESE TRIBUNALS MAY BE IMPROVED.

The Committee consisted of Mr. **William Fairbairn**, C.E., F.R.S., LL.D., &c.; Mr. **Joseph Whitworth**, C.E., F.R.S.; Mr. **John Penn**, C.E., F.R.S.; Mr. **John Hick**, M.P.; Mr. **Hugh Mason**, Mr. **Samuel Rigby**, Mr. **Frederick J. Bramwell**, C.E., Mr. **William Richardson**, and Mr. **Lavington E. Fletcher**, C.E.

I. Boiler explosions continue to occur with their accustomed frequency and fatality. Since the meeting of the British Association, held last year in Norwich, not less than 46 explosions have occurred, by which 78 persons have been killed, in addition to 114 others having been injured; and as these catastrophes take place with considerable regularity, there is every reason to apprehend that a similar number of explosions, causing the loss of a similar number of lives, and a similar amount of bodily injury, will transpire before the next meeting of the British Association, unless some very immediate measures are adopted for arresting these sad disasters.

The fearful explosion which occurred on the 9th of June last, at Bingley, by which as many as 15 persons were killed, and 33 others injured—some of them very seriously, will be fresh in the remembrance of every one; more especially from the fact that amongst those killed and injured were a number of women having no connection whatever with the works at which the explosion occurred, as well as a number of little children. These children were exercising in an adjoining playground, when just as they were passing close to the wall of a two-storied building on the premises at which the explosion occurred, the boiler burst, demolishing the building, burying the children in the ruins and crushing eight of them to death, in addition to seriously injuring 17 others.

Sad as it is when those connected with boilers and who gain their livelihood from working them are injured, it is even more so when outsiders who have no interest in their use or control over their management are victimised by their explosion, more especially when these victims are women and children. Such, however, is by no means an infrequent occurrence. In one case, a child asleep in its bed, unconscious of all danger, was killed on the spot by a fragment of an exploded boiler sent through the roof life a thunderbolt. In a second case a young woman working at her needle in an upstairs room in her own dwelling, was struck by a boiler which was hurled from its seat, and dashed against the window at which she sat. The injury she received was serious—her leg had to be amputed, and death shortly after ensued. In a third case, just as an infant was making its first assay at walking across the kitchen floor in a collier's cottage, a fragment of an exploded boiler came crashing through the roof, and striking down the child, killed it on the spot. In a fourth case, a woman was standing at her own cottage door with an infant in her arms, when one of the bricks sent flying by the bursting of a boiler, struck her little one on the head, and killed it in its mothers's arms. In a fifth case, a group of boys were sporting in a meadow, when the boiler of a locomotive engine, just drawn up at an adjoining railway station, burst, and scattering one of its fragments among the group, killed one of the boys on the spot, and injured another. In a sixth case, a house in which an infirm old woman lived, confined to her bed in an upstairs room, was demolished by a boiler explosion, so that the poor woman, with the bed on which she lay, were rudely brought to the ground. In a seventh case, a man passing through a public thoroughfare on horseback was struck by the *débris* showered around by a boiler that happened to explode at the moment; so that even those casually passing by the premises at which steam power is employed are not safe from the attacks of bad boilers. It is no uncommon thing for dwelling-houses in the vicinity of boilers to be invaded, on the occurrence of an explosion, with huge fragments, and to have their windows and roofs riddled as if they had been bombarded, while in some cases they are altogether demolished. Many other cases similar to the above might be added, but the facts already given are, it is thought, sufficient to show that those who use steam boilers are not only the parties who suffer from their explosion. Thus, the subject acquires a wider interest, and becomes not only important to steam users, but also to the public at large.

It is therefore desirable that public attention should be thoroughly aroused on the subject of steam boiler explosions while it is clearly well worthy of the consideration of the members of the British Association.

II. The Committee pass on the second place to state that the attention of its members has for years been directed to the cause of these sad catastrophes, and that they have invariably found that steam boiler explosions though so complicated and disastrous in their results, have sprung from causes of the simplest character.

In some cases explosions arise from the boilers having been originally malconstructed, the furnace tubes, for instance, not having been strengthened, as experience has shown to be necessary, by encircling rings or flanged seams, or other approved and suitable means; and, in consequence of the neglect of these simple precautions, which may readily be adopted by any one, a considerable number of furnace tubes have collapsed and ruptured, when the rush of steam and hot water resulting therefrom has been attended with the most disastrous consequences, and many lives have been lost. Explosions of this character are particularly prevalent in Cornwall, where it seems especially difficult to persuade steam users that a furnace tube can collapse from any other cause than that of overheating through shortness of water. This simple, but obstinate prejudice, makes Cornwall one of the most prolific counties for steam boiler explosions, and the Cornish boiler, which, when well constructed and strengthened in the furnace tube as just described, is one of the safest and most reliable of any, has been raised to the undesirable notoriety of being the most explosive, simply through the obstinate prejudice just referred to, so that the very county that gave this boiler birth and name is doing more than any other to damage its reputation.

Other explosions arise simply from defective staying, as in the case of the boiler that exploded at Aberaman on the 31st of May last, killing four persons, and injuring four others. In this case the front end of the boiler was blown out, consequent on the removal of the furnace tube in order to metamorphose the boiler, most unwisely, from one fired internally to one fired externally. When the furnace tube, which formed a most valuable longitudinal stay, had been removed, no adequate provision was made for its loss, and the consequence was that the end blew out from sheer weakness. This explosion is by no means singular, and many similar cases have been met with in which the flat ends of boilers have been blown out through unwisely removing the furnace tube in Cornish boilers in order to exchange internal firing for external. One other explosion, resulting from imperfect staying, may be referred to, which occurred on the 28th of July, 1866, at Tunstall, and resulted in the death of two persons and in injury to seven others. This boiler was of considerable size, being as much as 36ft. long by 9ft. diameter, while it was worked at a pressure of from 35lb. to 40lb. on the square inch, This boiler, which contained an internal horseshoe-shaped flue, was constructed with a hemispherical end at the back, and a flat one at the front. The flat end was insufficiently stayed, in consequence of which it was blown out with the horseshoe-shaped tube attached to it, and thrown to a distance of about 50 yards in one direction, while the shell of the boiler recoiled to about the same distance in another. Alongside this boiler was another, in process of completion, with two boiler makers and a boy at work inside it. On the occurrence of the explosion, not only was the boiler first referred to torn from its seat as just explained, but the sister one alongside was thrown on to a public road which happened to be on an incline, and sent rolling down the hill, with the men, the boy, and their tools inside it, so that their predicament was somewhat similar to that of poor Regulus when sent rolling down the hill in his spiked cask.

Other explosions occur from defective material and workmanship, in illustration of which the explosion may be referred to which occurred at Norwich on the 25th of September, 1866, by which the works were laid in ruins, seven persons killed, and two others injured.

Other explosions again arise from defective equipments, the manholes not being guarded by substantial mouthpieces, or the boilers not being mounted with suitable safety-valves, glass water-guages, or other necessary fittings.

Many explosions occur from the dilapidated state of the boilers, the boilers being worked on till the plates are so reduced as to be no thicker than a sheet of brown paper. One such case occurred on the 24th of April, 1865, at Wigan, and resulted in the death of one person, and in injury to four others. Another took place at Leeds on the 27th of March, 1866, by which two persons were killed and six others injured. A third happened at Collyhurst, Manchester, on the 23rd of December, 1867, by which six persons were killed and four others injured. Cases of this class are so numerous that they defy enumeration, and the working on of old worn-out boilers, that should long since have been discarded altogether, is a prolific source of explosion.

Some explosions arise from neglect of the attendants, through ignorantly tampering with the safety-valves, or neglecting the proper supply of water. The number of explosions from this cause, however, is not by any means so great in proportion to those that arise from mal-constructed or worn-out boilers, as is generally supposed, and many more explosions arise from bad boilers than from bad attendants, though it is often much to the convenience of the steam user to have the blame of an explosion thrown upon the attendant, rather than on the boiler.

Such are some of the leading causes of steam boiler explosions. all of which, it will be seen, are extremely simple, and the Committee consider that, as a rule, boilers burst simply because they are bad, bad either from original malconstruction, or from the dilapidated condition into which they have been allowed to fall, while they wish to record their opinion that these lamentable catastrophes, by which so many persons are annually killed, are not accidental, but that they might be prevented by the exercise of common knowledge and common care.

III. The next point the committee have to consider is, how far the present inquiries conducted by coroners as to the cause of boiler explosions are satisfactory.

On referring to the verdicts returned by coroners' juries on deaths occasioned by boiler explosions, it appears that the usual verdict is one of "Accidental death;" in fact, this seems to be returned on nearly every occasion, whatever the cause of the explosion may be, and even when it has resulted from the use of an old worn-out boiler, reduced to the thickness of a sixpence. Added to this, the evidence given at these inquiries is anything but of a reliable and instructive character. The most visionary theories are advanced, and the attempt is frequently made to show that explosions are unaccountable and inevitable. Thus, no suitable information is given to the public as to the cause of these sad disasters, and the consequence is that boiler makers can palm off on the public bad boilers, and the steam users employ them with the certainty that if they explode with fatal consequence, they will, by the help of a coroner and his jury, be publicly absolved from all responsibility, and the event proclaimed to be accidental. After the conclusion the committee have arrived at, that explosions are not accidental, but may be prevented by the exercise of "common knowledge and care," they cannot but consider that such evidence and such verdicts are eminently unsatisfactory, and that they call for immediate attention.

IV. In the fourth place the committee have to consider how far the present unsatisfactory character of coroners' investigations can be corrected.

It has been proposed by the Manchester Steam Users' Association that every coroner, when holding an inquiry on a steam boiler explosion, should be both *empowered* and *instructed* to avail himself of the assistance of two competent engineers having no connection with the works at which the explosion occurred, and that these engineers should visit the scene of the catastrophe, investigate the cause of the explosion, and attend the inquest, in order to assist the coroner in his examination of witnesses, as well as to give evidence themselves before the jury, and report on the cause of the explosion; their reports, which might either be joint or several as found most convenient in each case, being accompanied with explanatory scale drawings, showing the original construction of the boiler, and as far as possible the lines of rout, as well as the direction in which the parts were thrown, and the distances at which they fell, while, in order to secure to the public the full advantage of the investigation, the engineers' reports, with the accompanying drawings along with the verdict of the jury to be printed and deposited in the Patent Office, and lie there for inspection and purchase, as in the case of specifications of inventions, and further, that copies of these reports should be forwarded to the members of both Houses of Parliament, as in the case of reports on railway catastrophes, and also to the various free libraries and scientific societies throughout the country.

The committee consider that the adoption of this proposition would very much raise the character of the present inquires conducted by coroners, and that the measure is well calculated to secure the truth being fully arrived at, and plainly spoken, to which they attach the greatest importance.

The fact of two engineers being appointed to investigate and report, those engineers being altogether independent of the works at which the explosion occurred, would, it is thought, secure an unbiassed opinion, while from the publicity given to the verdict the coroner and jury would be stimulated to make a searching investigation. It is possible that in some cases, more especially in the early adoption of this plan, some coroners might not select the most competent engineers to assist them in their inquiry, but this it is thought is an error that would soon be corrected from the publicity it is proposed to give to the whole proceedings, which would make the coroners careful to make a wise selection for the sake of their own reputation, while as they would not be limited in their choice to a special locality, but might take the range of the whole country, there would be no difficulty in their finding thoroughly competent men. Were two competent engineers selected, the committee consider there would never, or at all events but very seldom be any practical difference in their views as to the cause of an explosion; but presuming that in a few instances such might be the case, the committee would not recommend that, as a rule, a third party should be called in to decide the point, since such a question should not be decided simply by a majority of opinions. The better plan would be to record the facts and the conclusions arrived at, and to leave to public discussion and time to show how far the opinions advanced were correct or not.

One of the results of searching investigations and plain-speaking verdicts would be—that when when a steam user has killed some half dozen people by the use of a crazy old boiler the widows and children of the deceased would be able to claim from him compensation for the loss of their breadwinners. This, it is thought, would operate as a most wholesome check both upon boiler makers and boiler users, as the one party would be exposed if he sold a bad boiler, and the other if he bought it. Some timid steam users object to this measure lest they should ever be brought in for heavy damages, but such fears may be altogether dismissed by all those who are working honest boilers. Good boilers, as already stated in this report, do not burst. Explosions are not mysterious, inexplicable, or unavoidable. They do not happen by caprice, or light like some deadly nightshade alike on the careful and the careless. They may all be prevented by the exercise of common knowledge and common sense, so that timid steam users may dismiss their apprehensions as long as they are doing their duty by their boilers and boiler attendents. These improved investigations would at the same time have a most wholesome effect upon the operations of the Boiler Inspection and the Boiler Insurance Companies, as in the event of the explosion of an enrolled boiler, the case would be fully investigated by impartial parties, and the facts brought to light. Such a course would clearly promote sound inspection.

Thus the committee consider that the adoption of this measure would have so wholesome an influence upon boiler makers and boiler users, as well as upon boiler attendants and boiler inspectors, and indeed upon all those connected with the use of steam, that it would, without any further Governmental interference, do much to prevent the recurrence of steam boiler explosions, and they warmly concur with the proposition.

With regard to the manner in which the expense of these investigations should be paid, the committee recommend that this should be met from the same source that coroners' inquiries are met at present, viz., either from the county or the city rates, as the case may be. This course is deemed better than that of throwing the cost of the inquiry upon the owner of the exploded boiler, by way of penalty, as in many cases he would be so impoverished by the catastrophe as to be unable to meet the charges, while in addition it is thought that scientific witnesses, called upon to discharge so important a public duty as that now proposed, should not be dependent on so uncertain and invidious a source for remuneration.

It has been proposed that the Crown should levy a heavy deodand on the owners of all boilers that explode, unless it could be shown that the explosion arose from causes entirely beyond their own control. the onus of the proof being thrown on the boiler owners, and not on the Crown. Such a measure has, at first sight, much to recommend it. It would doubtless act as a powerful stimulant to care, but inasmuch as the relatives of those killed by boiler explosions are deprived thereby of their means of support, it is thought that all payment should go to them in the way of compensation rather than to the Crown. In many cases the owner of a boiler is so impoverished by its explosion that, had he to pay a deodand, he would have nothing left whereby to compensate those rendered widows and orphans by the catastrophe, so that the Crown would be robbing them of their legitimate compensation. It is thought, therefore, it would be better not to impose any deodand, fine, or penalty, but to leave the steam user, in the event of explosion, simply to the exposure of full investigation and plain speaking, combined with the liability to an action for damages, for which the law at present provides, but which the improved verdicts would give increased facilities for setting in motion.

The committee would wish to add a few remarks upon the misapprehension that arises from the use of the word "*accidental*" in the verdicts returned by coroners' juries, and the advantage they think would be derived from the substitution of the expression "*not due to malice aforethought.*" The committee apprehend that the fundamental object of a coroner's inquiry in case of a sudden or violent death is to determine whether that death was occasioned by personal malice or not. Thus, it may be legally correct for the jury to return a verdict of "Accidental death" from a steam boiler explosion, though the boiler may have been so worn out that in an engineering and common sense view the explosion was no accident at all. Thus the jury use the word in one sense, but the public accept it in another, and the term is taken to be an exoneration of the owner of the boiler. It is thought that the obligations of the jury would be fulfilled, at the same time that the prevention of steam boiler explosions would be promoted, if juries, instead of returning a verdict of "*Accidental death,*" would state that they consider there had been no "*malice aforethought,*" and the following verdict is given by way of illustration:—

"The jury find that X., X., X., &c., were killed by a steam boiler explosion that occurred in X.-street, in X. town, on X. day of the week, month, and year, on the premises occupied by X., and while they consider that these deaths were not occasioned by any 'malice aforethought,' either on the part of the owner of the boiler or others connected with it, they wish to record the fact that the boiler was a bad one, its plates being considerably reduced by corrosion, and that it was to this cause that the explosion was due."

The committee do not overlook the fact that juries have a third course open to them, which lies between the announcement of "Accidental death" or "Wilful murder," and that they have the power of committing owners of boilers for "Manslaughter," a power which in many cases they are bound in the discharge of their duty to exercise, and in the opinion of the committee much more frequently than they do. The task, however, of committing a boiler owner for manslaughter is frequently an invidious one for a coroner's jury, and in practice, verdicts of manslaughter are very seldom brought in by them. Were the suggestion just made carried out, coroners' juries would be extricated from an unpleasant position, and the truth with regard to explosions would be more fully and freely spoken.

The following is a recapitulation of the conclusion to which the committee have arrived :—Firstly, that a lamentable loss of life is annually caused by steam boiler explosions, which urgently calls for public attention. Secondly, that these explosions, as a rule, are not accidental, but may be prevented by the exercise of common knowledge and common care. Thirdly, that the present investigations conducted by coroners with regard to steam boiler explosions are eminently unsatisfactory, and call for immediate improvement. Fourthly, that coroners should, when conducting inquiries on boiler explosions, be instructed and empowered to avail themselves of competent engineering advice, so that the cause of every boiler explosion may be fully investigated, while the information acquired should be widely circulated. Fifthly,—the Committee entertain a sanguine hope that this course alone would do much towards the prevention of the present recurrence of steam boiler explosions, without any further Governmental action.

Before concluding this report, the Committee feel it incumbent upon them to allude to the general movement that has taken place within the last year with regard to the adoption of some system of compulsory inspection.

During the past Session, a Bill was introduced to Parliament, and carried throught an early stage, for placing all steam boilers under Governmental inspection, by the agency of the Board of Trade. By others, it has been proposed that every steam user should be compelled to have his boiler examined and certified by some private association or company instituted for that object, and authorised by the Government. Others propose that insurance should be an essential accompaniment to this arrangement, and that, to secure the integrity of the service, the boiler inspectors should themselves be inspected by the Government.

With regard to these propositions, the committee would wish to express a strong and, as they think, a wholesome dread of any Government interference with the management of private concerns, and they cannot but consider that the plan proposed of handing over all the boilers in the country to the super-of the Board of Trade would prove harassing to the steam user, and a barrier to progress. Such a system it is thought must soon prove a system of limitation. Inspectors armed with Governmental powers must be guided by a code of rules laid down by some higher and central authority. They must be instructed what diameter of boiler, and what thickness of plate to allow for certain pressures of steam. Also what area and description of safety-valves and what number and description of fittings generally. Thus the responsibility of construction would be removed from the boiler makers to the Government, and the Board of Trade would become the national boiler constructors. However wisely and liberally such a system might be worked, and however carefully its code of rules might be devised, it is feared it would shortly prove an irksome limitation, and serious embarrassment result. Whether any milder measures could be introduced to extend the operations of private associations, is a question on which the Committee are not in a position to pronounce an opinion at present; but the subject appears to them to be one of considerable importance, and the more public attention is called to it, and the more it is ventilated and discussed, the better.

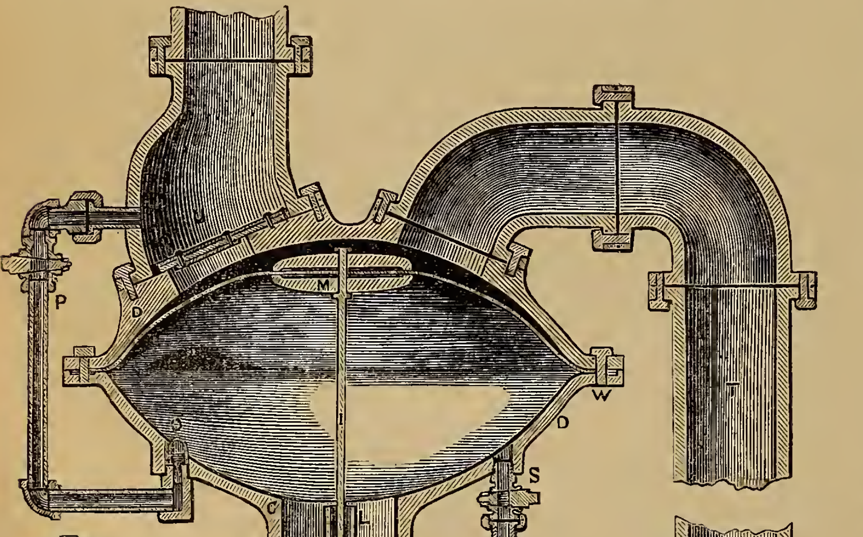
The Committee would venture, however, to submit to consideration, whether it would not be worth while to try the effect of more searching Coroners' investigations, and plain speaking verdicts, before any other steps are taken. Were the course recommended herein with regard to Coroners adopted, such a mass of well authenticated information would soon be accumulated, that it would be shortly apparent whether this measure were of itself sufficient to arrest the course of boiler explosions, or whether the recklessness of steam users was so great that more stringent measures were absolutely necessary; while, supposing that the latter unfortunately proved to be the case, the amount of authentic information obtained would form a sure basis for legislative enactment. The Committee therefore venture to urge that the plan proposed in this report be fairly tried before any further steps be taken, and they recommend this subject to the best consideration of this meeting of the British Association.

It should not be omitted to mention that since this subject was brought under the consideration of the Mechanical Section of the British Association last year, the Manchester Steam Users' Association memorialised the Home Secretary with regard to the improvement of Coroners' inquiries, in the manner referred to in this report. The deputation was favourably received, and the Home Secretary stated in his place in the House of Commons only a few days since, that he should endeavour, during the recess, to prepare a measure for the prevention of steam boiler explosions. Thus considerable attention has been drawn to this subject during the past year, and considerable progress has been made in educating public opinion with regard to it. The Committee think that this affords ground for congratulation, and that with the interest now aroused in connection with this subject, the attainment of the prevention of steam boiler explosions is not far distant.

Signed on behalf of the Committee,
William Fairbairn,
Chairman.

## IMPROVED PUMPING AND BLAST ENGINE.

We illustrate below a peculiar arrangement for a pumping or blast engine that has attracted considerable attention in America, the performance of which is said to be very satisfatctory. It is the invention of Mr. Shaw, of Philadelphia, and the following description which is given in the *Scientific American* thoroughly explains its action :—



The object of the inventor in designing this pump was to obtain the simplest and most efficient device for the purpose. It is well known that steam pumps in general are complete steam engines, having all the parts usually found in them. It will be seen by the engraving that this has no working parts that require packing, no metallic surfaces in contact, and that the details are limited in number; in fact, the only part moving is a cotton duck diaphragm, which has no friction whatever, and is simply a floating wall between the water to be lifted and the steam which lifts it. It follows from these facts that the resistance to be overcome before the work is done is reduced to nothing, hence no lubrication is required, and the total effect of the steam is applied directly to the water itself, the diaphragm aforesaid being the only object intervening.

The annexed engraving shows a vertical section through the centre of the pump, of which A is the base or standard, and D D are hemispherical castings of iron with flanged edges, united by bolts W. Intervening between said flanges, and stretching across said hemispheres, is a rubber-coated duck diaphragm, of sufficient diameter to allow it to float to the extreme upper and lower walls of the hemispherical disks, D D. The lower half of the hemispherical disk is coated with vulcanised rubber, thus preventing the too rapid cooling of the steam chamber. C is the wall of the hot well; U is outlet waterpipe with valve opening outward; T is inlet water-pipe, provided with valve K. opening inward; O is the injecting nozzle, provided with a valve opening inward. This injecting nozzle is connected by a small pipe, P, with outlet pipe, U. V is a steam pipe from boiler, provided with cock, R, and leading to steam chest, B, and also to starting cock, S. J is a tubular valve, with its seat at Q, and is provided at the bottom of this tube with a light coiled spring, as shown. I is a valve stem clasping diaphragm disks, M, and having a button or nut on its lower end, playing loosely in valve tube, J, for the purpose of operating valve, J, by opening it and closing it alternately at its seat, Q. E is a well for the collection of condensed steam; L is a pipe to conduct live steam from steam chamber, B, through the hot well to lower hemisphere; F is a pipe for the escape of condensed steam, with outlet cock, H, to limit the amount of escape, and has also a valve at G, opening outward.

The pump is operated by opening the cocks, R and S, which let steam into the body of it. The air contained therein is driven out through the pipe, F, when the cock, S, is closed. As soon as the steam in the pump is reduced to the pressure of the atmosphere, a jet of water will be thrown into the pump through the nozzle, O, which is supplied from the feed pipe, P. The steam is thus condensed, a vacuum is formed below the diaphragm, and it comes down immediately, followed by the water, which rushes in through the main suction pipe. In the act of descending the valve stem, I, attached to the diaphragm, strikes a spring at the bottom of the valve tube, J, and opens it at its seat, Q, which allows the live steam to enter the body of the pump directly under the diaphragm, and lifting the same, precisely as a piston would do, ejects the water, which entered at its down stroke. The injection water, of course, does not enter while the steam is under the diaphragm and doing its work, as the pressure prevents it, but so soon as it is expended, and the pressure reduced, the steam being condensed as before the diaphragm descends, and the pump acts automatically. The number of strokes per minute varies from five to ten, and the height to which the water is elevated depends upon the pressure of steam employed.

It will be seen that it takes steam only one way, and that the steam is condensed, showing a very marked advantage over pumps that take steam both ways, and exhaust it into the atmosphere or throw it away at every stroke. These pumps have been running for several months at the manufacturer's works, feeding boilers, and doing other work. They are said to have drawn water the full limit of distance allowed for atmospheric pressure, and through very many angles and crooked passages; the peformance leaves nothing to be desired. They are economical in fuel, act with great regularity, and require no attention after once starting.

## CORRESPONDENCE.

*We cannot hold ourselves responsible for the opinions of our Correspondents.*

### IRRIGATION IN INDIA.

Sir,—I have just received an official return of the areas irrigated in the North-Western provinces of India during the official year of 1868—69, which closed in April last, along with the orders passed by His Honour the Lieut.-Governor, on the subject, for which I trust you will find space, as it confirms what The Artizan said on the subject in May last.

Though this return does not show the areas watered by each canal, yet it is not difficult to arrive at an approximate and correct conclusion; for the last four districts mentioned, of which in all only equal 82,521 acres, were irrigated by the water courses in the Delhra Dhoon, and in districts east of the river Ganges; so, as the Eastern Jumna Canal can only irrigate portions of the three first districts on the list, it is evident that all the remaining irrigation is due to the Ganges Canal.

### PUBLIC WORKS DEPARTMENT.—Irrigation Operations of 1868-69.

*Comparative Statement of Irrigation in India and Rain-fall for years* 1867-68 *and* 1868-69 *in Canal Districts of the North-Western Provinces.*

| Zillahs. | Area in acres. | Cultivated area in acres. | Areas irrigated. *Fusl Khurreef*, 1868-1869. Total acres. | *Fusl Khurreef*, 1868-1869. In comparison with 1867-68. Increase. | *Fusl Khurreef*, 1868-1869. In comparison with 1867-68. Decrease. | *Fusl Rubbee*, 1868-1869. Total acres. | *Fusl Rubbee*, 1868-1869. In comparison with 1867-68. Increase. | *Fusl Rubbee*, 1868-1869. In comparison with 1867-68. Decrease. | Whole years, 1868-1869. Total acres. | Whole years, 1868-1869. In comparison with 1867-68. Increase. | Whole years, 1868-1869. In comparison with 1867-68. Decrease. | Percentages of Increase or Decrease in 1868-69. | Rain-fall. 1867-69. | Rain-fall. 1866 69. | Rain-fall. Percentage of Decrease in 1868-69. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. | 16. | 17. |
| *Saharunpore ......... | 1,425,825 | 1,001,518 | 48,629 | 3,770 | ... | 99,672 | 55,636 | ... | 148,292 | 59,406 | ... | 66 | 55·2 | 31·4 | 43·1 | Comparison with irrigation of 1860-61, the most recent famine year.<br>Khurreef, Rubbee, } Acres......... 1860-61. 730,351<br>1868-69. 1,425,702 |
| *Moozuffernuggur .. | 1,054,065 | 703,549 | 63,726 | 8,354 | ... | 140,433 | 85,408 | ... | 204,159 | 93,762 | ... | 84 | 47·6 | 20·0 | 58·0 | |
| *Meerut ............... | 1,511,661 | 1,082,196 | 106,904 | 48,237 | ... | 201,257 | 108,501 | ... | 308,161 | 156,738 | ... | 103 | 36·9 | 23·8 | 38·8 | |
| †Boolundshubur ...... | 1,221,373 | 823,004 | 45,583 | 23,440 | ... | 110,037 | 67,671 | ... | 155,620 | 91,111 | ... | 142 | 37·4 | 17·0 | 54·5 | |
| †Allygurh ........... | 1,190,118 | 932,640 | 46,351 | 12,892 | ... | 82,574 | 27,670 | ... | 128,925 | 40,562 | ... | 45 | 35·9 | 22·5 | 37·3 | |
| †Muttra } Doab | 1,032,021 | 831,124 | 8,772 | 4,247 | ... | 14,539 | 2,046 | ... | 23,311 | 6,293 | ... | 35 | 31·4 | 17·7 | 43·6 | |
| †Agra | 1,199,037 | 886,774 | 812 | 63 | ... | 1,029 | ... | 798 | 1,841 | ... | 735 | 28 | 37·4 | 19·2 | 48·6 | |
| †Etah .................. | 898,838 | 585,330 | 12,985 | 9,829 | ... | 22,768 | 6,959 | ... | 35,753 | 16,788 | ... | 84 | 49·8 | 16·4 | 67·0 | |
| †Mynpoorie ............ | 1,066,534 | 576,615 | 31,961 | 22,918 | ... | 66,554 | 21,256 | ... | 98,515 | 44,174 | ... | 81 | 51·9 | 17·5 | 66·2 | |
| †Futtehgurh ......... | 1,084,399 | 674,034 | 14,296 | 8,404 | ... | 29,905 | 17,014 | ... | 44,201 | 25,418 | ... | 132 | 52·6 | 16·5 | 68·5 | |
| †Etawah ............... | 1,041,123 | 572,221 | 33,083 | 25,185 | ... | 55,108 | 16,251 | ... | 88,191 | 41,436 | ... | 87 | 57·7 | 20·4 | 64·6 | |
| †Cawnpore ............ | 1,514,343 | 855,663 | 32,911 | 14,022 | ... | 73,301 | 37,313 | ... | 106,212 | 52,235 | ... | 96 | 60·8 | 50·9 | 16·2 | |
| Delhra Doon ......... | 653,271 | 866,657 | 4,144 | ... | 189 | 9,810 | 2,156 | ... | 13,954 | 1,967 | ... | 16 | 88·9 | 29·3 | 67·1 | |
| Bijnour ............... | 1,204,659 | 685,026 | 146 | ... | 867 | 1,509 | 856 | ... | 1,655 | ... | 1 | ... | 59·1 | 37·3 | 37·0 | |
| Terai .................. | 469,760 | 91,735 | 3,622 | } 12,304 | ... | 4,573 | 3,161 | ... | 8,195 | } 35,869 | ... | 120 | 72·7 | 37·4 | 48·5 | |
| Bareilly ............... | 1,518,579 | 1,084,290 | 29,319 | | ... | 29,398 | 20,404 | ... | 58,717 | | | | 65·3 | 45·8 | 30·0 | |
| Total ........... | 18,088,606 | 12,252,376 | 483,235 | 194,565 | 1,046 | 942,467 | 472,302 | 798 | 1,425,702 | 665,759 | 736 | ... | .. | ... | ... | ... |

Those Zillahs marked thus (*), it is calculated, are supplied to the extent of one-half by the Ganges Canal; and those marked (†) are entirely irrigated by the same canal.

Net increase.................................................................. 665,023 acres.

Return if estimated at Rs. 2-2 per acre irrigated will probably amount to Rs. 30,29,617.

The area irrigated is 89 per cent. larger than that of the preceding year, 95·89 per cent. more than the extent of land irrigated in the last famine of 1860-61, and 45 per cent. greater than in 1866-67, the previous maximum.

W. Jeffreys, Capt., R. E.,
Assistant to Chief Engineer, Irrigation Works.

14th July, 1869.

The only question to discover is, how much irrigation in these first three districts is due to each of the two canals which water the "Doab," and this may approximately be arrived at by referring back to the irrigation returns of former years. By going back three years to the official year of 1865—66, it will be found that only 160,356 acres were irrigated that year, by the Eastern Jumna Canal, and this after it had been open for 35 years, so making every allowance for the wetness of that season and the dryness of that just past, it would be a very liberal allowance to say that the area irrigated last year by this old canal might be double the area watered three years before.

| | | |
|---|---|---|
| This would give an area of | 320,712 | acres. |
| To which has to be added due to other canals | 82,521 | „ |
| Making a total to be deducted of | 403,233 | „ |
| From the total irrigation of | 1,425,702 | „ |
| Thus leaving a balance of | 1,022,469 | „ |

due to the irrigation from the Ganges Canal, which at Rs. 2-2-0, or 4s. 3d. per acre, amounts to £215,275, but as very nearly ten per cent. of the total revenue is due to navigation, mill rents, &c., the sum of £23,908 requires to be added, thus the total revenue from the Ganges Canal last year would be very nearly £239,183, instead of £250,000, or hardly five per cent, below the estimate given in The Artizan in May last, after making a most liberal allowance for the increased irrigation by the Eastern Jumna Canal.

Again, if one acre of land produces sufficient to feed three people for a whole year, which it is believed it can, some *three million* human beings have been fed by the Ganges Canal last year, and but for it a very large proportion of this number must have perished from starvation.

This has all been accomplished by a canal which was supposed to have been a failure, both in an engineering and financial point of view, but which I almost alone, for the past nine years, maintained was not the case.

Now that I have lived to see every word I have said, substantiated by official records, I think I have, sir, cause to feel gratified.

I remain,
Sir,
Yours obediently,
T. LOGIN, C.E.
Late Supt. Northern Division Ganges Canal.

Weston-super-Mare,
9th Sept., 1869.

Resolution No. 1,813, dated Allahabad, the 17th July, 1869.

Read—Comparative Statement of Irrigation and Rain-fall for the years 1867-68 and 1868-9 in canal districts of the North-Western Provinces.

*Observations.*—This statement simply exhibits in a tabulated arithmetical form the great work, with which the Lieutenant-Governor was already familiar, performed by the Ganges, Eastern Jumna, and Rohilcund Canals. It would hardly be possible to over-estimate the blessings conferred upon these provinces by the irrigation of over a million and four hundred thousand acres, the greater part of which would otherwise have failed to produce any harvest. The bare statement, taken in connection with the peculiar difficulties of the year, is the highest encomium the Irrigation Department can receive.

The Lieutenant-Governor will reserve further remarks until the detailed reports have been laid before him. But the statement now submitted contains so complete and satisfactory an epitome of the results of the year's administration, that His Honour is pleased to direct its early publication in the supplement to the *Goverment Gazette.*

By Order, &c.,
W. H. Greathed, Colonel R.E.,
Joint Secy. to Govt., N. W. P., P. W. Dept.

## NOTICES TO CORRESPONDENTS.

J. Thompson (Liverpool).—We have received your description of a new method of obtaining motive power, and are sorry to perceive that it is another attempt at perpetual motion—or, in other words, to get something out of nothing. We can only advise you to give it up, and turn your attention to something more practicable.

Napoleon.—Your scheme for a railway from Dover to Calais is decidedly too original and too grand for the columns of The Artizan. Try a comic paper.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

Painless Amputation.—Mr. H. B. McMasters, of Stockton, U.S., had four fingers completely severed from his right hand a short time ago by a circular saw, about which he was at work. He says he did not feel the act of amputation, and was not even aware of it until he saw the blood upon the board where he was at work. He resumed his place in the mill immediately after the wound was dressed. We commend this to the attention of Dr. Richardson.

The Cotton Crop.—The Cotton Commissioner for the Central Provinces of India and the Berars, in writing to the Bombay Chamber of Commerce on the 21st of last month from Nagpore, states that on the whole the prospects of the cotton crop in that district are favourable. The season, he says, has been a trying one, but the rain has always fallen when it was most wanted, and cultivators are in good spirits, and predict a good season. In the country above the hills to the south of Khangaon and Oomarstee, the rainfall has been abundant, and the cotton crop is reported to be forward.

Santiago-de-Chili International Exhibition.—Last year a notice was given in The Artizan that the Chilian Government would hold an agricultural exhibition, in which some large prizes were to be distributed to the successful competitors. A grand prize of a gold medal and 800 dollars, or £160, was offered for the best collection of agricultural machinery: and another of a gold medal and 500 dollars, or £100, for the best steam-thrashing machinery. Many other gold medals and prizes of smaller value were offered. English firms have carried off the lion's share of the prizes. Messrs. Ransomes, Sims, and Head, for their thrashing machine, got the first prize and gold medal; Messrs. Clayton and Shuttleworth the second gold medal. Special prizes were also gained by Messrs. Howard. American manufacturers came in second for chief prizes.

The Smoke Nuisance at Newcastle-upon-Tyne.—The committee appointed at the meeting held in the Guildhall, Newcastle, has had a conference at the council chamber, under the presidency of the Mayor. Considerable discussion arose as to the steps to be taken. The most perfect unanimity, however, prevailed as to the desirability of acting in such a way as not to embarrass unnecessarily the important manufacturing and mining interests of the neighbourhood. There is said to be a general feeling among owners of works, collieries, &c., that the time has come for doing something towards suppressing the nuisance. A sub-committee was appointed to inquire into all the plans proposed, or in operation, for the prevention of smoke and obnoxious vapours, and to report to the general comittee at their next meeting.

The Wolf Rock Lighthouse Door.—The brass door made for the Wolf Rock Lighthouse weighs 13 cwt., and cost £170. Where it will be fixed a door of solid oak, 4 in. thick, was shivered into fragments by the sea, and one 4 in. thick, strengthened by bars of iron 4 in. square, is *locum tenens* till the brass one be put up.

Electric Light.—The directors of the Transatlantic French Steam Navigation Company have entered into a contract for supplying to their vessels magneto-electric machines and other requisite apparatus for exhibiting on board during the night-time electric lights as signal-lamps. The superiority of this light is manifest. It need hardly be pointed out that, by adopting this mode of illumination, the directors of the aforesaid steam navigation company greatly increase the safety of their vessels. Electric light ought to be more generally used for this purpose.

A New Preservative against Fire.—M. Reinsch states that, having been requested to report to a fire insurance company about the best means of preventing timber bursting into flame, he experimented with various salts, and at last came to the conclusion as the result of his experiments, that impregnating timber with a concentrated solution of rock salt, is as good, if not better, a preservative against its bursting into flame as water glass (silicate of soda), while the price of the former salt is, of course, only a mere trifle; moreover, rock salt thus applied to timber is a preservative against dry rot and noxious insects. The author recommends the use of salt water, that is to say, a solution of rock salt of moderate strength for the use of fire engines during a fire as by far more effective than water; but in order that the salts should not injure the working parts of the engines, they will immediately afterwards have to be played with fresh water again.

What becomes of Old Shoes.—They are cut up in small pieces, and these are put for a couple of days into chloride of sulphur, the effect of which is to make the leather very hard and brittle. When this is found so have been effected the material is withdrawn from the action of the chloride of sulphur, washed with water, dried, ground to powder, and mixed with some substance which causes it to adhere together, for instance, shellac or any other resinous material, or also good glue or thick solution of gum; it is then pressed into moulds, and shaped into combs, buttons, knife hafts, &c.

The Cost of Purifying our Rivers.—An important experiment is now being made at Bradford with the view of purifying the polluted streams of the neighbourhood. Works have been erected by Mr. Holden for deodorising and utilising the sewage. The outlay in plant for the purification of 2,500,000 gallons of sewage per day, including the price of the 10,000 square yards of land required, the cost of tanks, necessary buildings, engines, tools, and everything necessary to carry on the process, would it is calculated, be about £14,000. The cost of conducting the process afterwards would be about 1d. per 1,000 gallons per day, or, for a town sending down 2,500,000 gallons of sewage, £10 8s. 4d. a day. Those who have seen the Bradford steam admit that if the experiment succeeds there, it need fail nowhere else.

### NAVAL ENGINEERING.

An Engineering Novelty.—Messrs. Stothert and Pitt, the well-known firm of engineers at Bath have just completed an important piece of machinery to be used in dock-making at Kurrachee, India. The Titan for so it is called, consists of a huge square frame with a long neck, constructed of iron girders and mounted on four wheels, so that it can run on a tramway. On the top of the frame at one end is a steam crane, while placed on the neck is an hydraulic crab. By means of this huge engine concrete blocks weighing 27 tons each will be deposited in their places in the dock which is being constructed at the above port. The Titan is somewhat of a novelty, and its weight is about 200 tons and has been satisfactorily tested up to 40 tons.

A 13in. sea-service mortar of five tons weight has been ordered to be converted upon Major Palliser's plan into a 9in. rifled mortar of about 6¾ tons weight, to fire the 9in. service rifled shell, which contains a bursting charge of 18 lb. of powder. The bore of the mortar will be elongated to about 4ft. 6in.; and a range of about 7,000 yards is expected to be obtained from a charge of 20 lb. of powder. Some further experiments are being carried on with two 10in. shell guns, which are being converted respectively into an 8in. and a 7in. rifled gun, in order to determine the most suitable calibre for the conversion of cast iron 10in. shell guns. The whole of the 212 8in. guns converted into 6·3in. rifled guns by Sir Wm. Armstrong and Co. have been passed into the service, and 200 more are in course of conversion in the royal gun factories. It is probable that a considerable number of guns will be converted next year for land defences, the whole of the above 437 guns being for the navy.

## LAUNCHES.

**Launch at Kinghorn of the Largest Vessel yet Built in the Forth.**—The largest iron ship yet built on the shores of the Forth was successfully launched on the 7th ult from Mr. Key's shipbuilding yard at Abden, near Kinghorn. The *Abden* is 305ft. in length between perpendiculars, and over all 320ft. In breadth of beam she measures 38ft.; while her depth of hold is 28ft. Her engines, which have been made by Mr. Key at his works at Kirkcaldy, are surface condensing, on the horizontal principle. They are 500 nominal horse power, and she is expected to steam at the rate of 13½ or 14 knots an hour. The diameter of the cylinders is 70in. and the stroke is 38in. Steam is generated in four tubular boilers, with four furnaces each. She is 2,167 tons burthen, builders' measurement. The *Abden* is a three-decker, and will be brig-rigged, with iron foremast and bowsprit. She is intended for the passenger mail service, but could be fitted up to contain 1,000 troops as a transport.

## DOCKS, HARBOURS, BRIDGES.

**Austria and the Suez Canal.**—The Vienna press strongly recommend Austrian merchants and manufacturers to make preparations for taking advantage of the new channel for Austrian commerce which will be afforded by the opening of the Suez Canal. Austria, they say, is already placed in a very advantageous position for this purpose by her seaports and railways, and when the southern lines, for whose construction preparations are now being made at Vienna and Pesth, are completed, the monarchy will be the best medium of communication with the East by way of the canal. At the same time it is pointed out that among the Austrian merchants, manufacturers, and shipowners, the greatest indifference prevails on this subject, and that there does not seem to be even any desire to obtain information as to the facilities for extending Austrian commerce in articles whose production is almost exclusively confined to the monarchy.

**New Iron Pier at Douglas.**—The town of Douglas in the Isle Man was all en fête on the 19th ult, on the occasion of the opening of the new Promenade Pier. The inaugural ceremony was performed by Mrs. Lock, the wife of the Lieutenant-Governor of the Island. The High Bailiff, complimented the contractor, Mr. John Dixon, of London, for the liberal and energetic spirit in which the work has been carried out. The first pile was driven on the 17th of last March, so that the entire structure containing many hundred tons of iron, has been completed within the short space of five months.

## RAILWAYS.

**Pacific Railroad.**—The passenger travel on the Pacific Railroad continues very heavy. Pullman is running two and sometimes three palace sleeping cars on each train, which are always full.

**The Elevated Railway in New York.**—A New York city daily states that "the first one of the cars of the West Side Elevated Railway has been completed and placed on the track. It is lightly but firmly built; is in appearance between a railroad and a horse car; is 27 by 7 feet in dimensions, neatly fitted inside with oak and black walnut, and is expected to seat forty people. The body of the car was made at Sandwich, Mass., and the running gear at the company's workshop in New York. The average rate at which the cars will run will be about 12 miles an hour, although it is anticipated that they can attain a speed of 25 miles an hour, if necessary. The *American Artizan*, commenting upon the above, says:—When the West Side Elevated Railway Company, on its scarcely rectilinear track and with its system of rope traction, runs a car filled with passengers at the rate of 25 miles an hour, "may we be there to see!"

## ACCIDENTS.

**Boiler Explosion.**—On the 16th ult there was an explosion of a boiler at the oil mills of Mr. Henry Hodge, of Holderness-road, Hull. It appears that the fireman was employed in firing up, when without any previous signs of the existence of defect, the boiler burst with a loud explosion. The fireman was carried by the force of the explosion over three adjoining two-storeyed buildings, a distance of thirty-four yards and dashed with his head against a wall. He was quite dead, and his body was fearfully disfigured. A youth who was near the boiler was much scalded. When the boiler was inspected, it was found that the explosion had twisted what was left of it to an inconceivable extent. The force of the explosion carried away and completely destroyed a large press in immediate proximity to the building where it occurred. It also carried away the roof of the premises and part of the walls. The boiler-house was razed to the ground, not the least part of it remaining standing. A large quantity of rubbish was carried a distance of two hundred yards.

## MINES, METALLURGY, &c.

**The Gold-fields in Scotland.**—The Kildonan diggings are still maintaining a struggle for existence, but it is only of a lingering description, there being now only some fifty diggers at work. They have, however, been pretty successful of late on the new piece of ground allotted to them on the burn beside the Kildonan tent village, but it is being worked out, and there is little hope that the diggers will get new claims marked out to them at the places where they desire when the present are exhausted.

**Mercury Mines of Almaden.**—M. Jonglet says that mercury, as metal, has been known from the most remote antiquity—that there have been mines worked for mercury ore in Asia Minor in the time of Xenophon: the mines of Alamaden, Spain, is yet the largest source of mercury for Europe. The cost of 100 kilos. of the ore is, everything included, only 16 francs and 10 centimes; but it yields, as this author, says by unsuitable management, only 6·9 per cent of mercury, 100 kilos. of which cost, on the spot, 141 francs and 30 centimes; but at Sevilla the price is already 177 francs and 80 centimes, in consequence of cost of transport and the iron vessels in which the metal is carried. The average quantity of mercury produced annually amounts to about 15½ tons, by weight.

The discovery of two new diamond-fields—those of the Cape and of Victoria—has come in good time to meet the demand. The East Indian supply has long since declined and the markets have of late years been dependent on Brazil. On the whole, the fashion for diamonds has declined, in Russia, Turkey, Spain, and Portugal, though a rise was created by the fashion in Paris under the Empire and in the United States. For small diamonds or diamond dust for trade purposes the want has increased, and the price sometimes reaches £600 per ounce.

## WATER.

**Inverted Syphon.**—A iron pipe, eleven inches in diameter and 8,800 feet (one and two third miles) long, has been laid in Tuolumne county, California. It runs down a mountain, under a creek, and up the ascent on the opposite side, under a perpendicular pressure at the lowest point of 683 feet.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| **COPPER.** | | | | | | |
| Best selected, per ton | 76 | 0 | 0 | 77 | 0 | 0 |
| Tough cake and tile do. | 74 | 0 | 0 | 75 | 0 | 0 |
| Sheathing and sheets do. | 78 | 0 | 0 | 79 | 0 | 0 |
| Bolts do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 81 | 0 | 0 | 83 | 0 | 0 |
| Old (exchange) do. | 65 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | ,, | ,, | ,, |
| Wire do. | 0 | 0 | 8¼ | 0 | 0 | 8½ |
| Tubes do. | 0 | 0 | 10½ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 7 | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6¾ | ,, | ,, | ,, |
| **SPELTER.** | | | | | | |
| Foreign on the spot, per ton | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. to arrive | 20 | 10 | 0 | ,, | ,, | ,, |
| **ZINC.** | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | 26 | 10 | 0 |
| **TIN.** | | | | | | |
| English blocks, per ton | 126 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 127 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 134 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 135 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 131 | 0 | 0 | ,, | ,, | ,, |
| **TIN PLATES.*** | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 8 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 14 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 2nd quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. Coke do. | 1 | 3 | 0 | 1 | 4 | 6 |
| IX. do. do | 1 | 9 | 0 | 1 | 10 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| **IRON.** | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 17 | 6 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 15 | 0 | ,, | ,, | ,, |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 0 | 0 |
| Bars do. do. | 7 | 7 | 6 | 8 | 0 | 0 |
| Hoops do. do. | 8 | 0 | 0 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | 6 | 5 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 7 | 5 | 0 | 7 | 10 | 0 |
| Do. Swedish in London do. | 9 | 17 | 6 | 10 | 0 | 0 |
| To arrive do. | 10 | 0 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 13 | 3 | 3 | 1 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| **STEEL.** | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 5 | 0 |
| Do. in faggots do. | 15 | 15 | 0 | 16 | 0 | 0 |
| English spring do. | 19 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| **LEAD.** | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 10 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 10 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | ,, | ,, | ,, |
| Spanish do. | 18 | 5 | 0 | ,, | ,, | ,, |

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*At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated August 20th, 1869.

2487 W. S. Sutherland—Welding plates of iron and steel
2488 A. Wigzell—Steam boilers
2489 W. Longbottom and A. Willan—Velocipedes, &c.
2490 W. Byrne—Distilling, &c.
2491 H. J. H. King—Measuring the flow or passage of liquids
2492 L. B. Fortin and J. Ferrahee—Manufacture of bats
2493 A. V. Newton—Paint

### Dated August 21st, 1869.

2494 W. Allan, W. Payne, and A. B. Fraser—Extinguishing fires
2495 A. Neill—Cutting or producing an even surface on stone
2496 G. W. Morgan—Life buoys
2497 J. Barlow—Toilet quilts
2498 F. Coote and F. W. Cranch—Improvements in velocipedes
2499 A. M. Clark—Springs
2500 P. A. Blake—Safety explosive compound for blasting, &c.
2501 J. Baur—Steel

### Dated August 23rd, 1869.

2502 H. Henchman—Windmills
2503 T. Gibb and C. Gelstharp—Extraction of copper from its ures
2504 N. Delandtsbeer—Combing machines
2505 H. A. Bonneville—Carding wool
2506 L. C. Girard—Railways, &c.
2507 T. Whitehead—Shackle or roller end for hardening machines, &c.
2508 W. R. Lake—Raising water, &c.
2509 W. R. Lake—Posts for gas lamps
2510 J. H. Johnson—Producing imitations and substitutes for wood

### Dated August 24th, 1869.

2511 J. Frengley—Tell-tale clock
2512 Z. Colburn—Construction and launching of subaqueous ways
2513 J. Williams—Junction of barrel for breech-loading firearms
2514 H. Taylor—Velocipedes
2515 F. Oakley—Holding firmly in their places bolt nuts
2516 J. E. Hodgkin—Breaking the woody parts of flax, &c.
2517 T. Briggs—Spinning cotton, &c.
2518 J. D. Nietscke—Preserving dead bodies
2519 J. Valters—Refining ale, &c.
2520 T. Webb—Ventilation of mines

### Dated August 25th, 1869.

2521 W. J. Cackburn-Muir—Permanent way of railways
2522 R. Maynard—Chaff-cutting machines
2523 C. Mackay and T. K. Wheeler—Cops for wefting, &c.
2524 T. Shakespear and G. Illston—Improvements in sewing machines
2525 O. Varley and F. H. Varley—Transmitting electric signals
2526 C. Cerisier—Ventilation of millstones
2527 T. Coley—Cultivation of hops
2528 W. R. Lake—Braiding machines
2529 H. Call—Machinery for obtaining motive power
2530 G. Zoeh and A. Lehmann—Yeast or artificial cement
2531 A. F. Cederweller and A. F. Westerlund—Porcelain-faience manufactory
2532 W. Brown—Disposing ships' cabins to prevent sea sickness

### Dated August 26th, 1869.

2533 C. D. Abel—Separating carded fleece into slivers, &c.
2534 H. P. Stephenson, E. G. Bartholomew, and R. King—Lighting gas lamps
2535 B. Hunt—Steam condensers
2536 H. Yates—Lace
2537 W. R. Lake—Carding fibrous materials

### Dated August 27th, 1869.

2538 E. A Cowper—Treating cast iron
2539 A. Moncrieff—Absorbing the force of recoil of ordnance
2540 J. M. Stanley—Iron and steel
2541 O. Vivier—Measuring the distance travelled by vehicles
2542 F. J. Drechsler—Stoves, &c.
2543 W. F. Gedge—Railway sleeper
2544 B. Hunt—Hulling coffee, &c.
2545 J. Teychenne—Additions to springs for mattresses
2546 E. A. Campbell—Coffee essence extractor
2247 W. R. Lake—Refining lard
2548 J. Fion and W. Charlet—Sash or framework for carriage doors
2549 S. C. Lister—Looms
2550 R. C. Rapier—Railway water cranes
2551 J. Ritchie—Tents, &c.

### Dated August 28th 1869.

2552 C. Duff—Paper pulp, &c.
2553 T. S. Blair and F. Ellerhausen—Treating conglomerates of cast iron
2554 J. Butterworth and J. Ainsworth—Mangling machines
2555 J. Spencer and J. Consterdine—Portable drilling machinery
2556 J. Holdsworth—Loading grain
2557 R. H. Herriott, C. Plumbe, and W. A. Pl—Communicating between passengers and guard of railway trains
2559 B. S W. Muir—Improvements in safety apparatus for steam boilers
2560 R. C. Robinson—Stove or fire grate
2561 J. Loader—Rotary engines
2562 R. Priestley—Fastenings for gloves

### Dated August 30th, 1869.

2563 L. Goldberg—Watches, &c.
2564 R. J. Westley—Constructing and converting billiard tables
2565 W. Young—Clarifying butter
2566 T Battell—Paper pulp
2567 W F. Williams—Boxes for holding jewellery and other articles
2568 W. Winter—Driving belt
2569 W. E. Newton—Nails, &c.
2570 H. E. Newton—Furnaces
2571 C. R. Stooke—Cages for mine shafts

### Dated August 31st, 1869.

2572 F. W. Potter—Wire work
2573 F Durand and C. Beslay—Applying the incompressibility of liquids, &c.
2574 A. P Trouchon—Elastic seats
2575 A. McNeile—Breaks for retarding the progress of wheeled carriages
2576 W. Glover—Looms
2577 W. E. Newton—Washing machines
2578 T. Coles—Wheels of carriages
2579 T. Wardlaw—Reaping machines

### Dated September 1st, 1869.

2580 T. Wilson—Screw wrenches
2581 J. Grice and J. G. Harrison—Improvements in axles
2582 J. Shand—Pumping engines, &c.
2583 S. Schiff—Filling pipes for smoking tobacco
2584 W. S. Laycock—Weaving
2585 G. H. Nussey and W. B. Leachman—Pressing woollen fabrics
2586 T. Greenwood and J. Bapty—Combing silk, &c.
2587 B. Isaugk—Indicating and registering the pressure of steam
2588 R. Scott and W. MacIvor—Treatment of hydrocarbon oils
2589 A. M. Davis—Alcoholic drinks

### Dated September 2nd, 1869.

2590 S. Willis—Railway chairs
2591 R. Pitcairn—Rest for supporting the arms of a person, &c.
2592 J. Day—Raising or closing the shutters of carriage doors
2593 P. McGough—Sash frames, &c.
2594 F. Prestage—Apparatus to be adapted to railroad carriages, &c.

### Dated September 3rd, 1869.

2595 R. D. Temple—Telegraph posts, &c.
2596 S. H. Greaves—Knives, &c.
2597 T. Slater—Construction of electro-magnetic machines, &c.
2598 A. M. Clark—Steam boilers
2599 H. Bridgewater—Railway chairs
2600 R. Spear—Transmitting power for operating marine signals
2601 A. Ogg—Printing machines
2602 W. H. Burnett—Modes of signalling on rail ways
2603 G. Henley—Dial telegraphs, &c.

### Dated September 4th, 1869.

2604 J. G. Lynde—Diaphragm indicator
2605 J. Webster—Nozzle for blowing air, &c.
2606 A. Defries—Novel application of glass to decorative purposes
2607 J. Juckes—Furnaces
2608 P. Spence—Improvements in the separation of copper from ores
2609 W. Ambler and B. Jowett—Method of advertising
2610 J. Hargreaves—Extracting phosphoric acid from the tap cinder of puddling furnaces and iron refineries
2611 W. H. Reade—Machinery for clipping the hair of animals
2612 J. Porteous and H. Gibson—Manufacture of tobacco
2613 W. Wright—Treatment of burnt cupreous pyrites
2614 F. H. W. Heuer—Velocipedes
2615 W. S. Clark—Boots and shoes

### Dated September 6th, 1869.

2616 C. F. Claus—Carbonate of soda
2617 T. S. Webb—Iron and steel
2618 J. Edwards—Railway carriages
2619 C. D. Escoffier—Casters, &c.
2620 E. T. Hughes—Doors, &c.
2621 T. H. Blamires—Rubbers for condensers and piecing machines
2622 W. E. Newton—Reaping machines
2623 F. Wicke, J. Brouner, T. Peterson, and J. G. Zehfuss—Treatment of human excrements
2624 W. E. Gedge—Rectifying alcohols
2625 S. F. Ibbotson and A. B. Ibbotson—Joints of railway rails
2626 W. R. Lake—Velocipedes

### Dated September 7th, 1869.

2627 R. Martyn, W. W. Martyn, W. C. Trevena, and T. H. Harry—Wheel huddle for dressing tin ores, &c.
2628 W. B. Thompson—Auxiliary screw propellers
2629 W. H. Richards—Nails
2630 S. Rawsthorne and J. Metcalf—Mules for spinning
2631 A. M. Clark—Ships
2632 F. Ellershausen—Utilising the force of the waves
2633 T. King—Pianofortes
2634 G Little—Telegraphic communications.
2635 A. V. Newton—Preventing the radiation of heat from steam boilers

### Dated September 8th, 1869.

2636 R. E. Hodges—Keyhole guides
2637 R. H. Hill—Crossings for railways
2638 H. D. P. Cunningham—Stands or racks
2639 H. B. Barlow—Knitting machines
2640 S. Oddy and R. Nuttall—Mules for spinning
2641 S. P Stewart and J. Kershaw—Locomotives
2642 K. Kraus—Watch protectors
2643 T. Walker—Electro telegraphy
2644 C. H. Murray—Screw propellers
2645 W. E. Newton—Packing for piston rods
2646 A. M. Clark—Dressing millstones
2647 A., G. and F. Earnshaw—Comparing musical keys
2648 J. A. Muller—Measuring and registering the flow of liquids
2649 W. Baines—Safety to railway trains

### Dated September 9th, 1869.

2650 W. Palliser—Rails for railways
2651 D. J. Williams—Movable partitions for the interiors of buildings
2652 F. Forder and J. J. Trnves—Bearings of loose axles
2653 J. Gillies—Bushes or shields for the bungholes of casks
2654 A. H. Gilmore—Shielding wounds
2655 H. A. Bonneville—Electric batteries
2656 W. T. Lillicrap—Carts
2657 J. A. Jaques, J. T. Oakley, and J. A. Fanshawe—Grinding
2658 D. Colville—Printing surfaces

### Dated September 10th, 1869.

2659 A. H. Brandon—Cartridges
2660 P. Hall—Transmitting motive power
2661 W. Murris—Cigars
2662 W. N. Nicholson and G. Black—Drills for sowing grain
2663 J. H. Johnson—Fastening for metallic hoops or bands

### Dated September 11th, 1869.

2664 W. R. Lake—Extinguishing fires
2665 L. Henriou—Combustion in fire-places and furnaces
2666 S. Simpson—Drawing fine wire
2667 B. Kershaw—Preserving food
2668 J. E. Moorhead and W. Dudgeon—Jacquard machines
2669 J. H. Johnson—Signals
2670 J. G. Tengue—Moulding
2671 W. A. Lyttle—Telegraph posts
2672 M. Andrew—Locks
2673 J. Betteley—Ships
2674 S. Fox—Railways
2675 J. B. Palmer—Matches

### Dated September 13th, 1869.

2676 F. S. Cocker—Velocipedes
2677 W. E Gedge—Preventing liquids from boiling over
2678 A. V. Newton—Extinguishing fires and watering streets
2679 C. Burke—Candles

### Dated September 14th, 1869.

2680 R. Lakin and John Bayley—Fibrous materials
2681 C. D. Abel—Preventing accidents through the closing of doors
2682 W. E. Gedge—Locomotion
2683 M. Grouse—Envelopes
2684 J. J. Bodmer—Iron and steel
2685 W. E Newton—Pumps
2686 W. E. Newton—Furnaces
2687 C. C. Steenstrup—Ordnance
2688 A. H. Gilmore—Safety lamps

### Dated September 15th, 1869.

2689 J. Holding and J. Eccles—Looms
2690 H. Alman—Ships' compasses
2691 P M Fouque—Holder for cartridges
2692 T. Restell—Breech-loading firearms and cartridges
2693 G. Shaw—Buckle and button hole
2694 G. Shaw—Furnaces
2695 W. E. Gedge—Geographical game
2696 C. G. Hill—Trimmings
2697 W. E Newton—Felt
2698 A. V. Newton—Engines
2699 C. Mohr and S. E. Smith—Cages
2700 A. M. Clark—Key guards

### Dated September 16th, 1869.

2701 H. B. Barlow—Preventing incrustation in boilers
2702 Wm. Bettison—Potters' glaze and seggar wash
2703 W. Tipping—Preventing or consuming smoke
2704 J Hampson—Pipes
2705 J. H. Johnson—Correcting the deviation of the mariners' compass
2706 C. Eskrett and Henry Searle—Envelopes or hairs used in extracting oil from oleaginous seeds, and oilcake making
2707 G. A. C. Bremme—Breaking and softening flax

### Dated September 17th, 1869.

2708 J. Sawyer—Furnaces for steam boilers and other purposes
2709 R. Stone—Construction of floors and roofs
2710 C. M. Waddie—Printing press
2711 O. H. J. Krag—Firearms
2712 A. Collingridge—Stowing and laying submarine cables

### Dated September 18th, 1869

2713 T. Wheatley and W. Wheatley—Fastenings for carriage doors
2714 R. S. Burkitt—Combustion of smoke in furnaces or fireplaces
2715 J. Belicard—Looms
2716 H. W. Harman and W. Lancaster—Steam boilers
2717 M. Amberg—Obtaining samples from bales of wool
2718 T. J. Denne and H. Billingsley—Producing transfers and blocks for lithographic and other printing
2719 N. J. Dor—Manufacturing crucibles, muffles, gas retorts, &c., through the agency of hydraulic presses
2720 C. Belier—Binding tapes
2721 A. Lacanso—Alarum
2722 H. A. Bonneville—Utilising the waste arising in spinning vegetable materials
2723 H. J Rogers—Scales
2724 J. G. Willans—Manufacture of iron and steel
2725 W. R. Eake—Galvanizing metals
2726 James Lee Norton—Looms
2727 C. Winn—Machinery for cutting or shaping metals

### Dated September 20th, 1869.

2728 S. A. Varley—Telegraphs, and in apparatus employed in their construction, part of which are applicable to other purposes
2729 J. N. Steiner—Construction and propulsion of velocipedes
2730 J. Polson—Treating grain
2731 A. Tylor—Preventing the waste of water and for cleanliness
2732 W. E. Gedge—Press bed
2733 M Doirier—Velocimanes
2734 P. Wisdom—Twisting and curling hair for use in stuffing beds
2735 W. A. Gilbee—Heating wines and other fermentable liquids, parts of such apparatus being also applicable to other purposes
2736 C. E Brooman—Chains and in the apparatus in connection therewith
2737 W. E. Newton—Machinery for the manufacture of tape trimmings
2738 C. E. Schoeller—Construction of copying presses

### Dated September 21st, 1869.

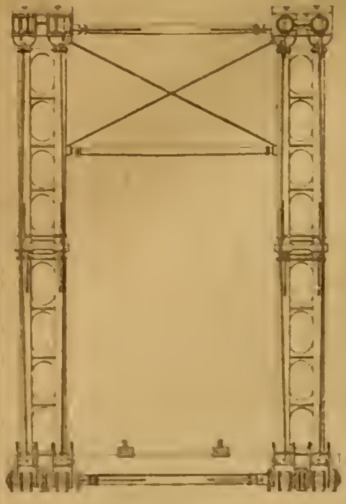
2729 H. Cockey and F. C. Cockey—Apparatus for scurfing retorts
2740 John Elee—Bobbins or spools, and in the machinery for winding rovings thereon
2741 R. Swift—Manufacture of iron kegs and other metal cases
2742 J. I'Anson jun.—Controlling railway switches and signals
2743 P. J. Kurtz—Chaff cutters
2744 J. Jacobs—Removing phosphates from ores and for utilising those phosphates
2745 W. R. Lake—Spindles and fliers of spinning frames
2746 A. V. Newton—Treatment of spirits or alcoholic liquids for the purification of the same, and apparatus therefore, a part of which invention is also applicable to the separation of the lighter from the heavier particles of oil and other liquids
2747 R. L. Hickes—Cartridges

### Dated September 22nd, 1868.

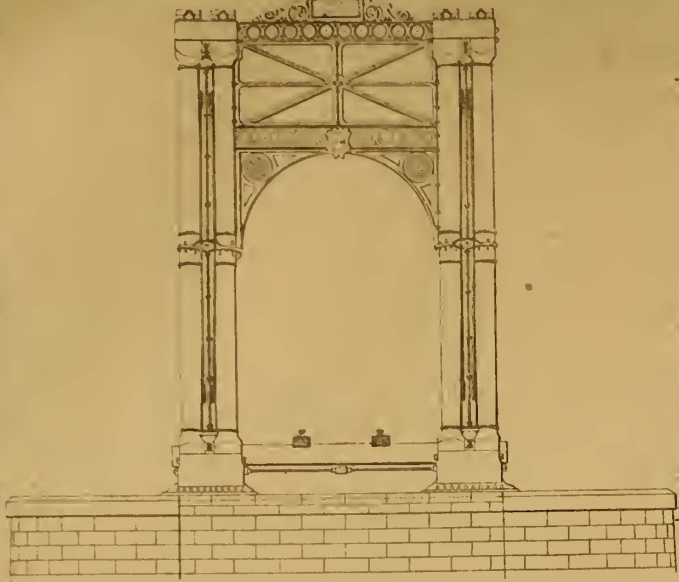
2748 M. Macleod—Apparatus for sanitary purposes
2749 J. Windsor—Dessicating and preserving potatoes
2750 G. H. Chatwin—Manufacture of umbrellas, parasols, and sunshades
2751 E. Hill—Slide valves
2752 R. R. Gibbs—Pumps, vacuum pumps, and blast engines
2753 W. J. Cunningham and A. P. McCarthy—Motive power
2754 J. Tarbuck and T. Burns—Pumping water from shafts or similar places
2755 C. L. Light—Construction of tram rails, in the modes of fastening the same, and in a mode of shifting carriages from one line of rails to another
2756 W. R. Lake—Purifying solutions of sugar and syrups
2757 W. R. Lake—Sewing machine and other needles
2758 A. V. Newton—Threshing machines
2759 H. R. Minns—Locking or securely connecting the doors of safes
2760 E. Hernulewicz—Securing the uprights o fencing

### Dated September 23rd, 1869.

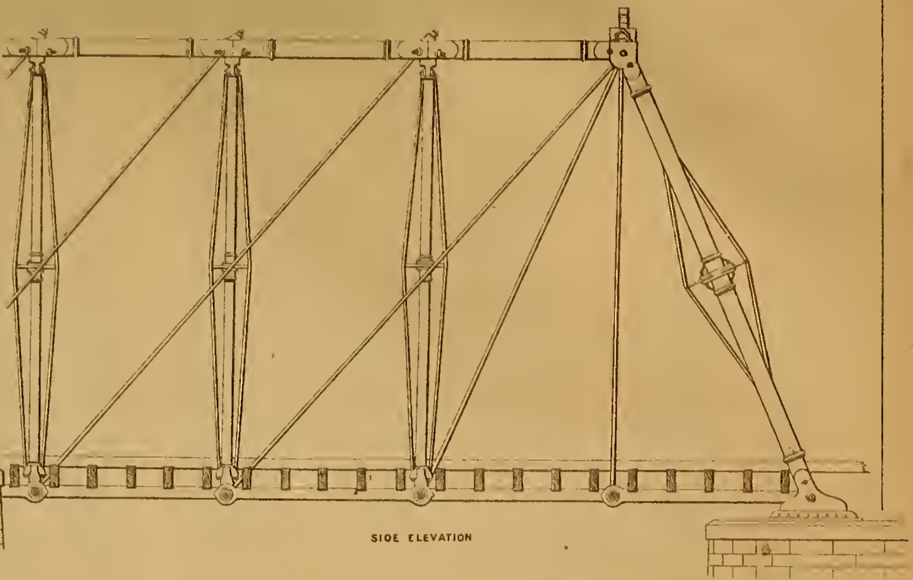
2761 W. Black and T. Hawthorn—Locomotive engines
2762 D. Witty—Propelling vessels
2763 R. C. Wallace and D. Crawford—Pumps and mechanism connected therewith
2764 J. Watson—Tyres
2765 V. Chemery—Damping and pressing the surface of cloth
2766 J. F. R. Badiou and F. Bernard—Shoes for horses
2767 W E. Gedge—Drying machine
2768 W. J. Turner and H. Yewdall—Manufacture of bisulphates
2769 F. Trench and E C. Warner—Horseshoes
2770 G. A. C. Bremme—Untwisting and unlaying threads
2771 J. M. Spence and J. B. Spence—Manufacture of disinfectants
2772 W. E Newton—Drying grain
2773 J. Mackenzie—Weighing machines
2774 J. B. Spence—Feeding steam boiler and other furnaces with fuel



CROSS SECTION



END VIEW

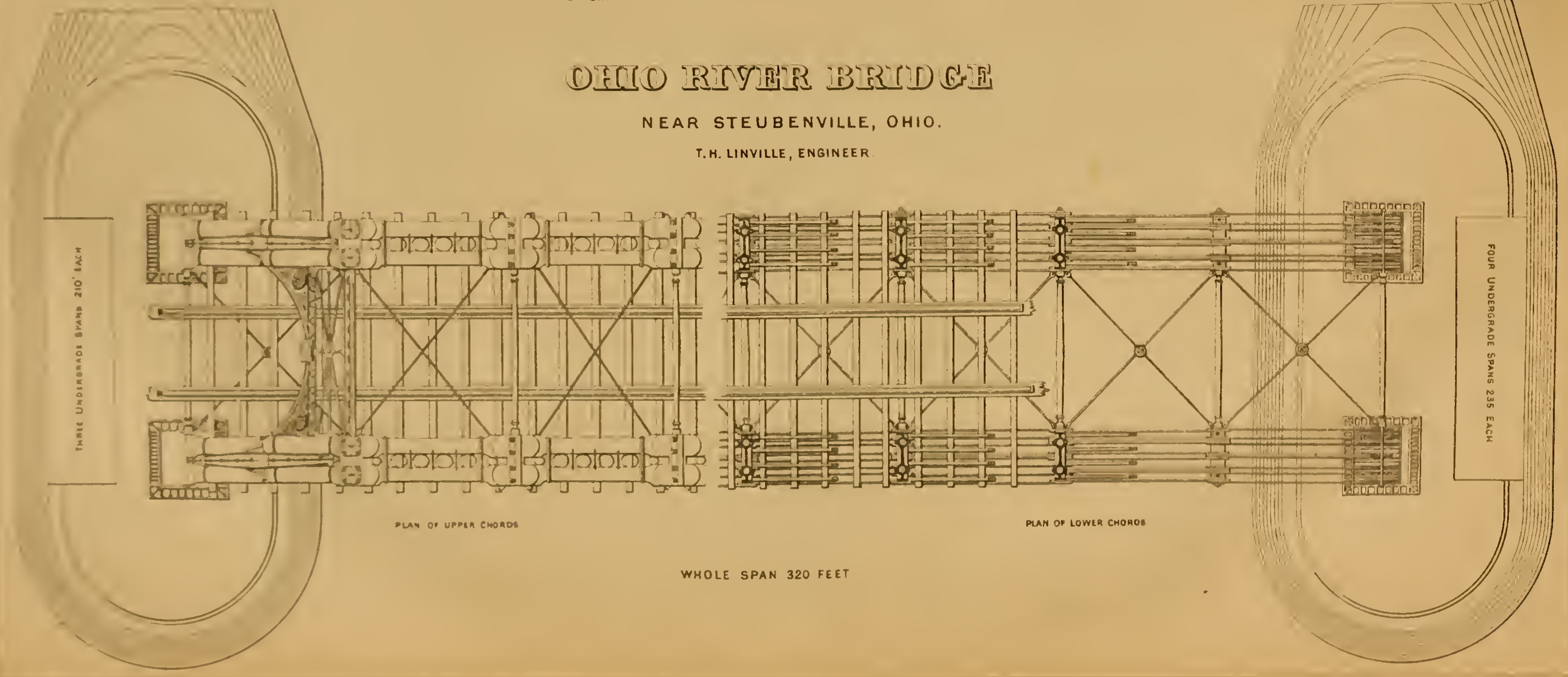


SIDE ELEVATION

# OHIO RIVER BRIDGE

NEAR STEUBENVILLE, OHIO.

T. H. LINVILLE, ENGINEER.



THREE UNDERGRADE SPANS 210' EACH
FOUR UNDERGRADE SPANS 235 EACH

PLAN OF UPPER CHORDS

PLAN OF LOWER CHORDS

WHOLE SPAN 320 FEET

W. Smith C.E. [illegible]

# THE ARTIZAN.

No. 11.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. NOVEMBER, 1869.

## OHIO RIVER BRIDGE AT STEUBENVILLE.

By Mr. J. H. Linville.

(*Illustrated by Plate* 354.)

The enormous dimensions of many of the rivers in America, combined with the great size of the steam vessels navigating them, present peculiar difficulties to the designing of bridges over them. As a favourable illus- of one of the modes of overcoming such difficulties, the bridge over the river Ohio, designed and carried out by Mr. J. H. Linville, may be instanced, more especially as it has furnished a type from which many other bridges have been modelled. An interesting description of this bridge has been furnished by Mr. Linville to the Franklin Institute, from which we extract the follow :—

A portion of the masonry for a bridge to connect the Pittsburgh and Steubenville Railroad with the Steubenville and Indiana Railroad, was erected in 1856, when the work was suspended. In 1862, the Western Transportation Company having arranged to complete the Pittsburgh and Steubenville Railroad to Steubenville, a lease of the franchises of the Holiday's Cove Railroad Company, with authority to erect the bridge over the Ohio River, was effected, and the work was executed under the auspices of the Trustees.

To the writer was assigned the duty of designing and superintending the erection of the iron superstructure.

By a revised location of some of the piers, the spans were reduced to four equal spans of 235ft. each, on the eastern side, between centres of piers, and three equal spans of 210ft. between centres of piers on the western side of the channel. The piers for the channel span are 90ft. in height above low water. They are 16ft. at the top, with a batter of 1 in 24. The adjacent undergrade spans are supported in a recessed chamber, four feet deep, in the sides of the piers, leaving an available thickness of 12ft. of masonry to support the channel span. The distance between the centres of these bearings is 320ft.

An act of Congress required the channel span to be constructed so as to afford a clear opening of 300ft. between the piers and a clear height of 90ft. above low water.

These requirements rendered it necessary to support the track of the channel span on the lower chords; an arrangement which impairs in some measure the beauty and symmetry of the entire structure.

The bridge company desiring the completion of the structure in 1863, without in any manner obstructing the channel, no system of wrought iron construction then in use appeared available.

A selection had consequently to be made from the plans of composite structures in use, none of which had been extended to spans of so great extent. The Linville and Piper patent truss was modified to meet the requirements of this particular locality, and adopted by the bridge company.

The description will be limited to an explanation of the peculiarities in the construction of the span over the channel.

The trusses are divided into 24 equal subdivisions 12ft. 3in. each, with two end panels 12ft. 6⅜in., making the entire length from centre to centre of bearings 319ft. 0¾in.

The height from centre of the lower chord to the top of the upper chord, at extremities is 28ft., the upper chord having a camber of 9in., the posts radiating so as to render their bearing surfaces normal to the curve of the upper chord.

The lower chords consist of 8 lines of Linville and Piper's patent upset eye bars, graduated in section to resist the maximum effects of the dead load, and of an uniformly distributed travelling load of 3,000 pounds per lineal foot of superstructure, together with the transverse strain from the floor timbers, without producing a tensile strain in these bars, exceeding 10,000 pounds per square inch of sectional area.

The lower chords and the looped ends of the suspension diagonals are combined by means of connecting pins 4½in. in diameter, the suspension diagonals being so disposed between the chord bars and ribs on the bases of the posts as to produce a shearing strain only in the connecting pin.

The upper chords consist of two similar tubes of cast iron, having an external diameter of 15in. at centre of each section, and slightly tapering towards the ends. These two sections are combined by intermediate cast iron ribs and webs, and terminate at the abutting surfaces in two double rectangular tubes with vertical ribs, between which pass the suspension bars.

By combining these tubes, greater width of abutting surface and consequently greater lateral stiffness was obtained. Under a maximum load the stain per square inch on upper chords does not exceed 10,000 pounds. The posts are also twin tubes of cast iron, 8in. in diameter, combined by intermediate webs and ribs, and made in two sections, with flanged ends, through which and the intermediate parting plate, pass 16 bolts 1¼in. to 1in. diameter, securely combining the two sections of the posts to the parting plates and to each other. The parting plate has four projecting pieces, with concave bearings, to receive truss rods, which are secured near the top of the posts, and deflecting eighteen inches, bear against the parting plate at the centre of the posts, and passing through shoulders near the bases of the posts, are adjustable by screws and nuts at their lower extremity. The posts are graduated in thickness by Hodgkinson's formulæ, the factor of safety being assumed at one-eighth of the breaking weight. The suspension diagonals consist of four square bars, varying in section in proportion to the strains, and were rolled in one piece, without welds. The lower ends have loops or eyes, 4½in. in diameter, which receive the connecting pins.

At the upper ends, the section of the bar is circular, formed by upsetting the iron in moulds, under immense pressure, and then swaging the ends. Screws are then cut, the available section of the bar at this point, after deducting screw-threads, being equal to the sectional area of the square bar. The upper and lower lateral rods are graduated in size, decreasing from 1⅝in. diameter at the extremities of the span, to 1⅛in. diameter at the centre. The lower lateral rods have welded loops passing through eyes in the wide eye plates, secured on the ends of the connecting pins. They meet in a ring at their intersection, and are adjustable by screws and nuts. The upper lateral rods pass through the cast iron chords, and are adjustable by nuts bearing against angle bosses cast on the chords. A system of diagonals is also introduced between the posts and upper chords, the strut being placed at sufficient height to clear the traffic.

Heavy cellular pier plates of cast iron are interposed between the bases of the end columns and the masonry.

At one end provision is made for variations in length arising from changes in temperature by means of a series of rollers secured in a frame of wrought iron. The track is supported on longitudinal timbers of white oak, resting on the transverse white pine floor timbers, which are sustained by the wide thin eye bars that constitute the lower flange or chord. In consequence of the heavy Government contracts incident to the late civil war, and the scarcity of skilled labour, great delay was experienced in procuring the requisite materials; and the progress of the work was frequently interruped. The erection of the shorter spans was begun in 1863. The channel span not being completed ready for erection during the stage of low water in 1864, its erection was deferred until the summer of 1865. To keep the channel open, and avoid risks from summer freshets, a wooden pier and two trestle abutments 40ft. in height, were erected to support two spans of wooden Howe truss bridge, on which were placed wooden trestles 25ft. in height, to carry the iron superstructure of the channel span. The erection of the channel span occupied about three weeks. The entire work was completed in August, 1865, without accident.

The general design of the deck spans is similer to that of the channel span. The end posts are vertical. The upper chords consist of cast iron tubes to resist the compressive strains, with two lines of rolled I beams, one at each side of each tube, to sustain the floor timbers supporting the track.

The channel span was fitted in the shops of the Pennsylvania Railroad Company, Altoona.

The Keystone Bridge Company of Pittsburgh were the contractors for the manufacture and erection of the seven deck spans, and the erection of the channel span; also, at the same time, for the manufacture and erection of the great double track iron span of 265ft. over the Monongahela River at Pittsburgh, the long line of plate bridge in South Pittsburgh, and the iron bridge at Saw Mill Run, all for the same line of road. The channel span over the Monongahela was constructed from the patterns of the channel span at Steubenville, such modification being made as were necessary to adapt the bridge for a double line of rails.

All these bridges have been constructed by the aid of the most approved machinery; the bearing being actually planned and the eyes in the eye bars of chords being drilled with so great accuracy that no variation exceeding 100th part of an inch was allowed. To test the strength of the large tubes, and the wrought iron bars, chords, &c., a hydrostatic testing machine was provided, capable of exerting a compressive force of 675 tons on columns 3ft. diameter and 30ft. in length, and a tensile strain of 130 tons on bars 40ft. in length, or on any intermediate size; thus enabling the engineer to test to the proof strain, all the materials used in these structures.

Owing to unavoidable delays in the preparation of this machine, it was possible to test only a few of the posts, chords, bars, &c., but the results demonstrated conclusively the accuracy of the data from which the proportions of the tubes had been determined.

The completed structure was tested by passing a train of engines and cars loaded to their utmost capacity with railway bars, the load entirely covering the channel span, and amounting to about $1\frac{1}{4}$ tons per lineal foot. The deflection being carefully indicated by a pencil point on a rod fixed to the scaffolding, free from the structure, did not exceed five-eighths of an inch. The weight of cast iron in the channel span is greatly increased by the material consumed in the webs and ribs combining the twin chord tubes and posts, also in the additional system of transverse struts to resist the effects of the diagonal bracing. By combining the posts and chords in this manner, the effective width of each truss was increased to 45in. thus adding to the lateral stiffness of the posts and chords, and ensuring the lateral stability of the bridge. This system of combining and trussing the posts was new and untried. This span was the pioneer of long spans of iron truss bridges on this continent, and to ensure success it was deemed prudent to allow considerable margin on the side of safety.

The weight of cast iron consumed in the construction of the channel span was 2,136 pounds per lineal foot, and of best refined wrought iron 1,423 pounds per lineal foot.

The line was opened in September, 1865, and since that time the bridge has sustained the constant heavy traffic without developing any defects, or requiring adjustment.

## GOVERNMENT CIVIL ENGINEERS AND COMMISSION ON CONTRACTS IN INDIA.

The following offensive notice has lately been issued to the civil engineering profession in India:—

"Public Works Department.
"*Notifications Establishment.*
"Simla, 31st August, 1869.
"No. 242.

"Whereas the Governor-General in Council is given to understand that, in the Civil Engineering profession in England it is a recognised practice for civil engineers employed by public companies and otherwise to receive, in addition to the salaries paid them by their employers, commission on contracts given out, or stores and materials ordered or inspected by them, and other like pecuniary considerations for services done, or intended to be done, which are considered legitimate sources of emolument; and whereas a considerable number of civil engineers, who have practised in England, have lately been employed by the Government of India, and the number of such engineers is likely to increase.

"1. It is hereby notified for general information that every person in the service of the Government in the Public Works Department, in any part of British India, whether civil or military, must consider his salary or pay, as regulated by the rules of the department for the time being, or defined in any agreement with the Secretary of State for India in Council, and whether it is drawn wholly or in part in the Public Works Department, or the Military Department, to be his sole legal remuneration; and that the receipt of commission, or any other consideration whatever, directly or indirectly, on account of any business or transaction in which he shall be concerned on behalf of the Government, whether in India or elsewhere, is prohibited.

"2. Every officer of the Government is bound to report to his department every infringement of the above rule which may come to his knowledge."

Upon which the Calcutta *Englishman* makes the following pertinent remarks:—

There can be little doubt that the notification issued by the Governor-General in Council with regard to the commission which his Excellency was "given to understand" was received by Civil Engineers on Contracts, and passing stores and materials, was couched in needlessly irritating language. It made a wide and sweeping accusation against an honourable profession, through whose exertions the greatest benefits conferred by English rule on India have been carried into effect.

Though presumptively fixing the blame on the profession in England, it by implication casts a slur of the very gravest character upon the numerous body of Civil Engineers employed in the Public Works department. This slur has been felt quite as keenly by the engineers of the various railway companies as by their brethren in the Department. It is felt that the effect of the notification is to lower the profession in the public estimation and to represent them as doing habitually that which the commonest honesty and fair dealing towards their employers would forbid. It is not asserted that Civil Engineers in India have been guilty of the practices condemned; the obnoxious order rests apparently upon nothing stronger than the suspicion of the Government of India that some members of the profession at home are not so honest as they should be. A public notification like this might very properly have followed upon the conviction before a proper tribunal of some member of the profession who had brought himself within the danger of that section of the penal code which forbids the reception of an illegal gratification; but in the absence of any such conviction—nay, more, in the absence of any arraignment of any officer whatever, either before a court or departmentally—it must be conceded that the publication of the notification was about as ill-advised and ill-considered a proceeding as was ever perpetrated, even by the Public Works Department.

We are quite sure that Lord Mayo, who has the credit of infusing new life and new vigour into the Public Works Department, will acknowledge that without some fault proved against the profession in India, such a notification ought never to have been published. Men smarting under a sense of wrong, and feeling that they are regarded with the most dishonouring suspicion by their superiors, and the head of the Government, are not likely to serve the state with that zeal, earnestness, and devotion which, considering the gigantic schemes it will be Lord Mayo's duty to inaugurate, it should be his object to foster and encourage. There can be no honour in a service where the servant is so suspected; and thus this notification is not unlikely to drive away from the service of the Indian empire men whose labours will be in greater and greater demand. With a revolutionised railway system and the spread of irrigation—progress in which has hitherto been to a great extent stopped for want of engineers and engineer officers—it should be the policy of the Government to create an Indian engineer service, and to hold out such inducements as should tempt to India the *élite* of the profession. Sir John Lawrence pointed out to the

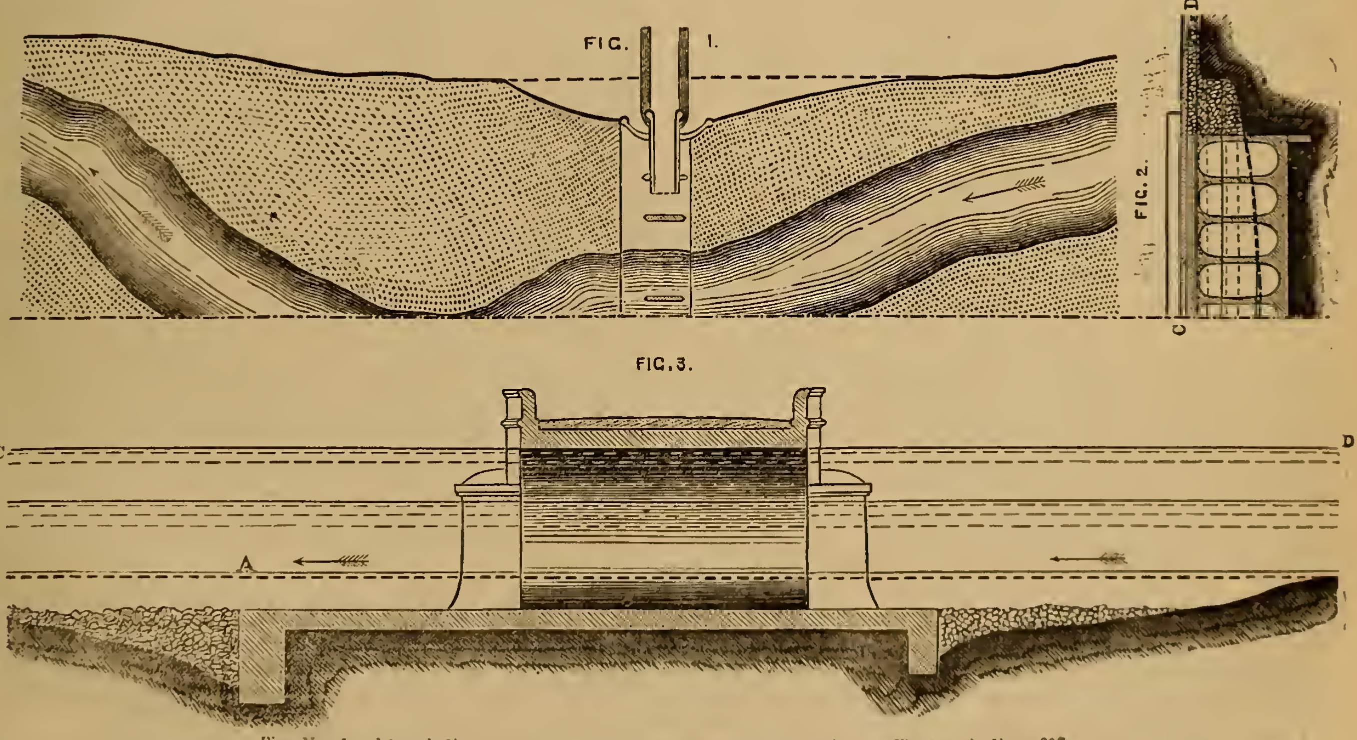
Secretary of State that the demands for engineers could not be met from the supply afforded by the Military Engineering Colleges. This being so, it does seem folly to do that which must make service in India distasteful to those gentlemen who are in India, and repulsive to those who might be induced to adopt an Indian career.

The notification will be heard of again, and in England. We have reason to know that several gentlemen of standing and repute in the profession have sent a copy of the "Gazette" in which it appears to the President of the Institute of Civil Engineers, with a request that he will take measures to vindicate the honour of the profession, and to clear the English members from the aspersions cast upon them.

## BRIDGES IN NORTHERN INDIA.

In the last paragraph of Mr. Login's paper "On Roads and Railways as affected by the Abrading and Transporting Power of Water," read before the British Association at Exeter, and which appeared in The Artizan of last month, he refers to a modification of the syphons as applied to bridges, an illustrated diagram of which we were unable to give at the time. The subject is an important one, and as it is believed the introduction of such a system of bridges would lead to great economy, we now publish this diagram. The spoon-mouthed syphon, to which he also refers, was illustrated in The Artizan of June last.

No. 6.—PROPOSED BRIDGES OVER SECOND-CLASS RIVERS.



Figs. Nos. 1 and 2, scale 1in. = 200ft. Fig. 2, vertical scale, 1in. = 100ft. Fig. 3, scale, 1in. = 20ft.
Note.—Section of stream in flood, 5,000 square feet; waterway of bridge about the same; waterway at A 7,000 square feet.

The object to be gained in this new description of bridge, is to show how sufficient water-way to a bridge may be given without necessitating heavy embankments, so that in the event of an extraordinary flood, which occurs about once in a generation, the flood may pass over, or even through the embankment without causing much injury. Thus the injury may be repaired at a trifling outlay, and without causing any appreciable inconvenience to the public.

To construct bridges sufficiently large to pass off the entire volume of water in extraordinary floods, would require an enormous expenditure: besides the existence of heavy embankments during such extraordinary occasions, causes the whole action to be confined to the bridge itself, and should it be injured it would involve a great outlay and loss of time to the public. We do not suggest this description of bridge for railways, but for district roads which act as feeders to the main lines of communication throughout India.

## THE ROYAL ALBERT HALL OF ARTS AND SCIENCES.

On the 20th of May, 1867, the "first stone" of the Royal Albert Hall of Arts and Sciences was laid with all due solemnity and ceremonial by her Majesty the Queen; and now, at the end of little over two years, the vast building is nearly completed, and is only waiting to be covered in by its vast roof to allow of all its interior fittings and arrangements being set up. In form it bears some resemblance to a Roman amphitheatre, although its material—namely, red brick faced with terra cotta—goes far to destroy the illusion. Still, it is only justice the architect to admit that the general effect of his work is both pleasing and imposing. Its magnitude will be best indicated by giving the exact dimensions in figures. The long diameter of the outer wall is 272ft., the short 238ft., the length between the porches 338ft., the breadth of the ellipse 332ft., and the height 135ft. The interior is arranged to accommodate comfortably an audience of 8,000, to be divided as follows:—In the arena, situate in the centre of the building, 1,000 can be accommodated for the musical performances, and when the space is not occupied, by a flower show or an industrial exhibition. The amphitheatre, which rises gradually all round the arena under the boxes, will hold 1,400, the boxes 1,100, the balcony 2,500, and the gallery 2,000. The boxes have already been all subscribed for at £1,000 each, and a great number of the single seats at £100, but it is calculated that between 5,000 and 6,000 sittings will still be available as a source of revenue for carrying out the objects of the hall. The building is now complete both as to its outer and inner walls, between which, it should be mentioned, run vast and airy corridors for promenade as well as ingress and egress. The next great work will be the fixing in its place of the immense roof of iron and glass, for the purposes of which the whole interior of the building is at present filled with a perfect forest of scaffolding. This roof will be greatest span of any work of the kind yet erected. Its long diameter will be 219ft. 4in.; short, 185ft. 4in.—an immense weight, it will be said, to be self-sustained. As, however, the calculations have all been made for lead where glass is only to be used, there is every reason to calculate on its strength and durability.

The only remarkable feature remaining to be noticed is the great organ in course of erection by Mr. Willis, the builder of the organ in St. George's Hall, Liverpool. Its dimensions will be 75ft. wide at base, 44ft. in depth, 60ft. width, and height 100ft. There are to be 112 steps, and the bellows is to be kept going by two steam engines of from 6 to 8 horse-power each. The largest organ at present known is the great organ at the Crystal Palace, but in the Kensington instrument the smallest pipe in the front will be longer than the longest pipe in the interior of its Sydenham predecessor. It is expected that the whole work—building, organ, and approaches—will be finished so as to open simultaneously with the projected international industrial exhibition in 1871, and that one of the earliest uses to which it will be put will be the ceremonial distribution of the prizes which will arise out of those exhibitions. The entire programme of its contemplated uses comprehends congresses national and international of science and art, performances of music on the grandest scale, distributions of prizes by public bodies, art and science conversazioni, agricultural, horticultural, and industrial exhibitions, and the occasional display of pictures and sculpture. For this latter purpose there will be an immense top-lighted gallery running all round the hall. It is satisfactory to be able to add that, in a building which is intended to accommodate assemblages of 8,000 persons, due care has been taken to provide ample facilities for entrance and exit.

## MYSTERY IN THE TICKETS.

We are indebted to a San Francisco paper—the *Mining and Scientific Press*—for the following account of an ingenious method by which non-transferable season tickets are protected from abuse :—

In the simplest manner, by the aid of Mr. Geo. F. Pardy's device, the Directors of the Fair have declared, and effectually made, the season tickets this year non-transferable. Many have deemed the report concerning the use of such an invention as unfounded, but they can satisfy themselves, if they choose, by trying the experiment of swindling the doorkeepers. Without more ado than by three or four stamps on your card, the clerk puts down your sex, complexion, approximate age and height, and describes your beard, moustache, and whiskers precisely. The ladies are not so closely looked after. Certainly it will not do any longer to attempt to use "one ticket for a whole boarding-house." The stamped season ticket is quite popular as a puzzle, and is not found fault with by honest people. Last year it is is estimated that from 5,000 dols. to 10,000 dols. was short, owing to dishonest transfers. Wherever now the personal characteristics are found to disagree with the stamps on the tickets, the latter is confiscated.

## H.M.S. "GLATTON."

This turret ship which is in course of construction at Chatham Dockyard will be the most powerful ship, for offensive and defensive purposes, yet built. The *Glatton* is being constructed from the designs of Mr. E. J. Reed, C.B., and the utmost exertions are being used to have her completed as early as possible in the ensuing year. From the circumstance of the *Glatton* being the first vessel built by the Admiralty on the pure turret principle, with an exceedingly low freeboard, more than the usual amount of interest is taken in her construction. She will be constructed with a single turret, in which will be placed a couple of 25-ton guns. The thickness of the armour plating on her sides will be no less than 12 inches above the water line, and the remainder 10 inches in thickness, worked to a teak backing of 20 inches. The inner skin plating to which the timber backing is attached consists of two thicknesses, each one inch thick, laid on the usual iron frames 10 inches deep, placed two feet apart. The total thickness of the iron and teak of the *Glatton's* sides will thus be 3 feet 8 inches. The armour plates on the turret will be 14 inches in thickness in the most exposed parts, and 12 inches thick in the remainder, worked on a backing of teak of 15 inches, with two thicknesses of skin ⅝ inch each. The entire base of the turret is enclosed by a breastwork carried to a height of 6 feet 6 inches above the deck, the whole being covered with armour-plating 12 inches in thickness, laid on a backing of teak 18 inches thick. The turret guns will fire over the breastwork, the *Glatton* when in action having a freeboard of only two feet, measured to the deck, the turret guns being exactly 11 feet 6 inches above the water line. This arrangement of breastwork possesses the advantages of raising the turret to a convenient height, whilst at the same time it affords great protection to the lower part of the funnel, hatchways, and other necessary openings from the deck. The arrangements for the turret are such that the 600-pounder guns will command a fire round the bows, to within about 20 degrees of the fore and aft line on each side; while a single gun can be trained and fired from this line round to a right aft fire on each side. On the top of the breastwork the plating is 1½ inch thick, and on the deck outside the breastwork 3 inches thick. When not in action her mean draught of water, forward and aft, will be 19 feet, but she can be submerged to any depth by means of water ballast, pumped into tanks specially fitted for this purpose. At her 19 feet draught her deck will be only 3 feet above the water, her armour extending 4 feet below and 2 feet 6 inches above the water, a 6-inch oak deck covering the upper edge of armour. Above the breastwork will be fitted a flying bridge, from which on all ordinary occasions the ship will be conned; in action, however, an armour-plated conning tower, specially fitted for this purpose, will be used. Stowage accommodation is provided for 250 tons of coals in her ordinary bunkers, but this quantity can be increased to between 500 and 600 tons by using the water-ballast tanks for stowing the coals. She is to be fitted with engines of 500 horse-power nominal, capable of working up to 3,000 horse-power actual, and her estimated speed will be from 9½ knots to 10 knots per hour.

## TECHNICAL EDUCATION FOR IRELAND.

The programme of the Royal College of Science for Ireland for the session 1869-70 has just been issued. It supplies, as far as practicable, a complete course of instruction in science applicable to the industrial arts, especially those which may be classed broadly under the heads of mining, engineering, manufactures, and agriculture, and is intended to aid in the instruction of teachers for the local schools of science. The course of instruction extends over three years, each year being divided into two terms. In the first two years the instruction is general, and all students are required to attend all the courses, but in the third year the particular business or profession to which the student intends to follow in after life is taken into consideration, and for this reason the studies for the third year are divided into four distinct series of courses, so that a student intended for an engineer is not required to study subjects useful only to an agriculturist; nor is a student whose after life is to be spent in a manufactory required to learn land-surveying and geology. During the third year the instruction for the several classes of students embraces: Mining—Geology, with demonstrations in Palæontology, Mineralogy, and Mining, Assaying and Metallurgy, Mechanism and Machinery, and Land Surveying; Agriculture—Geology, Agricultural Science, Land Surveying, Mechanism and Machinery, and the Analysis of Soils and Manures; Engineering—Mechanism and Machinery, Mechanical Drawing, Engineering and Surveying, and Geology and Palæontology; Manufactures—Applied Mechanics and Physics, and Applied Chemistry and Technical Analysis. The diploma of associateship, which will be granted to those who pass in all subjects of the first two years, and in those of any one division of the third year, will doubtless be an honour worth striving to attain; but there are also four royal scholarships of £50 yearly each, with free education (including laboratory practice), tenable for two years, which will be open to students who have been a year in the college—two of these royal scholarships become vacant each year. There are also nine royal exhibitions, of the value of £50 per annum, entitling the holders to free admission to all the lectures, and to the chemical and metallurgical laboratories, to be held from year to year, for three years, on the condition that the holder attends the lectures regularly during those years, and passes the examinations required for the associateship of the college—three of these exhibitions will be open for competition annually at the May examinations of the Science and Art Departments. A medal is also awarded at the conclusion of the second year's studies to that student who, upon the total result of both years, shall have most distinguished himself, if sufficient merit be shown. The fees are extremely moderate. No pains appear to have been spared to make the college of sound, practical utility to the largest possible number of those upon whom the continually progressive advancement of the industrial interests of the country depends; and with the Royal College of Science for Ireland in existence, there will be no justification for asserting that, at least in that portion of the kingdom, there is any lack of means for securing an abundance of technical education of the best kind and upon the most favourable conditions.

## THE SUEZ CANAL.

The following are the rules for the navigation of the Suez Canal:—

Article 1.—That the navigation of the Suez Canal be opened to allow all vessels without distinction of nationality, provided they do not draw more than seven metres fifty centimetres (7m. 50c.), equal to 24ft. 7in. English; the canal being eight metres (8m.), in depth, equal to 26¼ft. English. Steam vessels will be allowed to navigate through the canal using their own propellers; sailing vessels above fifty tons will have to be towed with the service established by the company. Steamers requiring to be towed can enter into a mutual agreement with the company. Towed vessels will have to provide their own hawsers.

Article 2.—The maximum speed for vessels in the canal is provisionally fixed at ten kilometres (10 kil.), equal to 5·4 English knots per hour.

Article 3.—Each vessel measuring more than one hundred (100) tons will have to take a company's pilot whilst passing through the canal, who will furnish instructions as to the course to steer, the captain remaining responsible for the conduct and management of his vessel.

Article 4.—When a vessel wants to pass through the canal, and has anchored at Port Said or Suez, the captain must have her inscribed at the transit office, and pay the canal dues, as well as pilotage, towage, and charge for mooring when necessary. A receipt will be given which he can use when required. He will have to furnish the following particulars:—Name and nationality of vessel, name of captain, name of owners and charterers, number of passengers, size of the vessel according to the legal measurement constituted by the official act of the Government to which she belongs.

Article 5.—In order to form the trains of towed vessels, the captain will be furnished with a ticket numbered, using his receipt of the charges as a way-bill, and after having received the pilot on board will place his vessel in the position assigned to her.

Article 6.—Vessels entering the canal will have to brace and peak yards. There ought to be two anchors, one placed at the head of the vessel and the other at the stern, and ready to let go so as to bring up at the first order of the pilot.

Artical 7.—1st. Each vessel will require a boat in tow, with a warp all ready to run ashore in case of need to one of the mooring posts attached to the banks of the canal. 2nd. The captain must also have watchmen kept on board the vessel during the day the same as at night. These men will be ready to cast off or cut the ropes at the first order. 3rd. During the navigation in the night vessels must keep their lights burning regularly, and a man forward on the look out. 4th. All steam vessels, tugs, or others, must whistle when passing the curves at the approach of vessels which they have to pass or cross; also at the approach of dredgers or any other objects they may meet in their passage. 5th. Vessels meeting in opposite directions must slacken speed, each standing close to the starboard bank, or stop according to the advice of the pilot. 6th. When a vessel wishes to pass another going in the same direction, the captain must signal his intention to the other. The slowest vessel must stand close to the starboard bank, and lessen her speed as much as possible.

Article 8.—1st. Vessels which for any cause whatever may have to stop in the canal must place themselves as near the windward shore as it is possible, and moor at both ends. 2nd. In case of necessary stoppage, and when a proper mooring station cannot be reached (which the captain always should try for), he must have immediately signals placed by day, and lights by night, fore and aft of the vessel. 3rd. In case of a vessel grounding the company's agents have the right to prescribe the means for getting her afloat, or discharging the cargo if necessary, all at the cost of the person in fault, to be determined by the cause of the accident.

Article 9. 1st. Captains are not allowed to moor in the canal except in cases of urgent necessity, and with the advice of the pilot. 2nd. Nor to throw any ballast, cinders, or rubbish, or anything whatsoever into the canal. 3rd. In case of anything whatsoever falling into the canal a declaration of the same must be immediately made to the pilot, who will forward it the nearest station. 4th. It is prohibited to captains to search for any objects that may fall into the canal, without the authority of the company's agents. 5th. The salvage, whatever way it may be effected, of any objects which may have fallen into the canal is always done at the expense of the captain to whom the recovered articles are returned on repayment of the expenses incurred.

Article 10. Captains have to agree before entering the canal to obey all instructions contained in the copy of the present rules, and to further their execution.

Article 11.—The tolls for the right of transit are calculated on the measurement tonnage of the ship, as likewise the charges for towing and berthing. This tonnage is determined, until fresh orders, by the official papers on board. The toll for passage from one sea to the other is ten francs per ton measurement and ten francs each passenger, payable on entering either at Port Said or Suez. The charge for towage is fixed at two francs per ton. The charge for berthing or anchoring either at Port Said, Ismailia, or opposite the new embankment near Suez (after a stay of twenty-four hours, and limited to twenty days at the utmost), is five centimes per ton per day, at the place assigned by the harbour-master. Pilotage is charged according to the draught of water. It is fixed as follows:—

| | For each decimetre in draught. |
|---|---|
| Up to 3 metres (9ft. 10in. English ... ... ... ... ... | 5 francs. |
| From 3 metres (9ft. 10in. English) to 4·50 metres (14ft. 9in. English) ... ... ... ... ... ... ... ... ... ... | 10 ,, |
| From 5·50 metres (14ft. 9in. English) to 6 metres (19ft. 9ft. English) ... ... ... ... ... ... ... ... ... ... | 15 ,, |
| From 6 metres (19ft. 9in. English) to 7·53 metres (24ft. 7in. English) ... ... ... ... ... ... ... ... ... ... | 20 ,, |

Each decimetre (4in. English) in draught pays proportionally to the category to which the vessel belongs. The pilot kept on board in case of berthing will have to be paid 20f. per day.

Vessels towed will be allowed a reduction of 25 per cent. off the charge for pilotage.

(Signed) **Fred. De Lesseps**, President.

Paris, 17th August, 1860.

## THE ECONOMICAL PURIFICATION OF ZINC CONTAINING IRON.

By W. H. Chandler.

In the galvanising of iron, the article to be galvanised, after being thoroughly cleansed, is dipped into a kettle of molten zinc, which forms an alloy with the iron at the surface of contact, and by repeating the dipping the thickness of the superimposed zinc may be increased at pleasure. In the prosecution of this manufacture, the zinc is held in large iron troughs or kettles, which are rapidly corroded in those parts nearest the fire. An alloy of zinc and iron is formed, to which also the articles, being galvanised, in some degree contribute. This alloy being heavier than the purer zinc sinks to the bottom, and, from time to time, is removed by perforated ladles.

The composition of the alloy is of course somewhat variable, depending upon the temperature and fluidity of the zinc and the careful straining from the fluid metal. The two analyses here given were made by the writer a number of years since:—

| | | |
|---|---|---|
| Zinc ........................................ | 94·27 | 94·15 |
| Iron ........................................ | 5·46 | 5·00 |
| Lead ........................................ | 0·27 | 0·56 |
| Tin ........................................ | trace | 0·29 |
| | 100·00 | 100·00 |

These samples were taken from a re-melting of a large quantity of the alloy, which is the only practicable method of obtaining a fair average specimen.

The quantity of this dross or refuse is quite considerable, amounting probably in the United States to several hundred tons per annum. Formerly it was sold for use in coarse brass castings, and to some extent it was redistilled. At one establishment in Boston circular clay retorts, similar to those in use in the gas manufacture, were employed, the molten alloy being introduced through an inverted syphon in the iron mouthpiece and the condensing tube connected with the reverse end of the retort, dipping in a pot of molten zinc; thus all access of air to the interior of the retort was prevented, and little or no oxidation of the zinc occurred.

Several years since a small lot of this refuse zinc was received at a metallurgical establishment in Massachusetts, in which the writer was employed as chemist, and, in experimenting upon it, one of the foremen of the establishment originated a method by which the zinc could be obtained quite free from iron. Finally, after rebuilding his furnaces and in various ways altering and modifying his manipulations, the samples of purified zinc being analysed after each alteration of the process, a good commercial article was obtained containing only one-tenth of one per cent. of iron.

The process consists in melting the refuse in an iron kettle, raising the heat nearly to the point of volatilisation of the zinc, and then, by a proper regulation of the heat, cooling the mass slowly from the bottom by means of a special arrangement of flues. An alloy of zinc and iron, containing a much larger percentage of iron than the original refuse, gradually forms, falls to the bottom of the kettle, and is removed by a perforated ladle. while the fluid metal is much purer. The quantity of alloy to be ladled out depends upon the impurity of the original refuse. The purified zinc and the concentrated impurity are melted in separate kettles, and each treated as in the first operation.

One more fusion and refrigeration of the purified zinc and the still more impure zinc render the former a good commercial spelter and the latter too impure for further economic treatment.

This process is the reverse in its reactions from Pattison's process for desilverising silver-lead ores. In the latter case the purer lead crystallises from the more fluid lead and silver, whereas in the former the more impure alloy separates from the purified zinc.

The residue from this process, which is sold for distillation, consists of hexagonal prismatic crystals of a fixed alloy of iron and zinc, loosely agglomerated together so as to crumble in the hand.

When the operation of refining is badly conducted, more or less zinc acts as a solder for the crystals. They are beautifully iridescent, exhibiting all the colours of the rainbow, owing to a surface oxidation. A number of specimens of varicus colours were selected for analysis and showed a composition of—

| | |
|---|---|
| Zinc | 90·50 |
| Iron | 9·50 |
| | 100·00 |

Upon fusing these crystals, which requires a high temperature, and cooling as before, a small percentage of purified zinc is obtained, and an alloy containing as much as 12½ per cent. of iron. This is compact, somewhat brittle, and exhibits no evidences of crystallisation.

This last-mentioned fusion is not made in practice, as the great heat required for its accomplishment rapidly burns out the iron kettles.

By a similar process lead has been removed from zinc with great accuracy, the amount obtained closely approaching the quantity therein. From a lot of Silesian spelter was separated lead perfectly malleable, and containing scarcely a trace of zinc. The purification of the lead, obtained from the process of desilverisation of silver-lead by means of zinc, could undoubtedly be accomplished by a modification of this process.

## PATENT LAW.

### The Bovill Litigation.

*(Continued from page 224.)*

We must now follow the judgment as it deals with the evidence not used in Bovill *v.* Keyworth.

Now, I take the Isleworth Mills. It is very important to look exactly to that case to see how that is introduced. I think I may safely say that there is no dispute now, in fact, as to what was really done at the Isleworth Mills. I think the mode in which it was introduced was a mode which I do not in the least suppose it was intended—I do not throw out any imputations at all, nor have I any doubt about it—but the mode in which it was introduced was a mode which would have misled me, until it came to be explained how the thing was constructed, and until we had the model—until everybody had agreed upon it; for it was quite clear when you came to consider the model and had the whole case before the court, what was really done. I describe what was really done as this, and I shall presently refer to what was said to be done by Mr. Kidd by which I should have been misled if I had not had the subsequent evidence. What was done by Mr. Mather and by Mr. Kidd anterior to the date of this patent was this: Mr. Kidd, like everybody else, though not using a blast, found the inconvenience of stive—that is a further corroboration of what I was saying that great inconvenience was found by everybody—the stive went down into the room below, as they blew through the stones, and the mill was in this condition. You had a floor, where the meal was delivered beneath the stones, then there was the stone floor; then there was the engine floor (that makes the third floor); then there was the bin floor (the fourth); and then the stage floor, which was the fifth. I am now describing the case as it stands on the whole evidence; and the process which was suggested by Mr. Mather to Mr. Kidd's mind was this. Hot air will naturally ascend; and, therefore, if you let the hot air ascend, the air coming very much heated through the stones you will get a good deal of the stive off with it. And they first began by simply putting up three feet of length of square wooden tubing —I call it "tubing" for want of a better word, although the word "tube" generally implies something round; but we will say a square tube. That was three or four feet above the stones. Then, as they expected, and might well have expected, the hot air arose, and, with it, carried the stive and came out; but then it was as bad in the stone floor as in the other room. That they found inconvenient. Then they went a step further, and introduced these upright tubes from several sets of stones (it is a very large mill, and there are three divisions of the mill)—they applied it to each division having a good many stones—they applied it first to one division, and then from each pair of stones carried up these tubes and carried them into a long horizontal tube which led under the engine room (by engine room understand the machine floor); then they carried it through the engine room, in which engine room was placed a sort of "cage"—I do not exactly know how to describe it—something like what the plaintiff calls the stive room—there was a thing with porous fabric hanging about it; then it passed through that up into the bin floor (it was in the bin floor that this thing was found), then it went up into the stage floor where there was a little box put round it, and then after a time, for it was a gradual process, they put a fan at the top of this series of tubes in the stage floor which went outside the building. One just sees at once what a difficulty there would be in making such an apparatus as that draw off the plenum. Now, perhaps, this would be the better place to say what I consider the "plenum" to be. It is only what Lord Campbell considers plenum to be—the quantity of air, which, according to what Mr. Gamman says, blew out the canvas, when it came out of the millstones—that extra quantity of air, which the centrifugal force of the stones produces, and by forcing the air through the stones, and inflating any flexible matter, and if it was in a box, pressing on any air that was to be found in the box. The object being to carry off this plenum only, there you had this long apparatus; and as I have described it as it really existed, with a fan not placed in the tube, being a very imperfect mode of exhausting the stive, but placed really outside it, so as to draw through all this stories, by means of having to pass through the chamber, where the air had free admission, through this sort of sacking, so that the power of exhaustion, whatever it was, must have been of the feeblest imaginable kind when it got to the top, and the best you could do with it was, to get it up to this height, and to dispose of it outside. Now what did happen was just what one would have expected would happen; and it is clear to my mind the mode of exhausting the plenum had not been arrived at; the air had never been drawn up and exhausted by means of this contrivance, where you had but one continuous close tube, with a fan on that close tube, with an area existing between them, except where the fan was drawing it up, so that the air would be exhausted to any degree you like, adjusting the amount of air so as to make it neither too little nor too great. You have nothing of the kind here; but the air would rise up, as it appears it did rise up, from its own natural levity, if I may use that term—from its own natural thinness or levity—it did rise up to a certain extent; there would be a certain feeble degree of exhaustion produced by such an apparatus as this at the top; and in going up feebly in this way the air would lose a great deal of its heat, the stive would be capable of being used, and fall in moisture and damp, and the consequences would be that when you got to the upper room, such stive as did get up there by reason of its own natural thinness, and with the slight assistance of the air being slightly exhausted in the upper regions, it did arrive in such a state that the moisture fell with the stive, and there was that clammy substance produced, which beyond all controversy was in such abundance that it had to be removed, certainly weekly, if not oftener—it certainly required to be removed weekly—in order to carry off to the pigs; it was a nasty, dirty, clammy substance which had been obtained. Now, I am to ask myself, whether this is the process by which the plenum is exactly adjusted, as we we find in other cases, and in the experiments which took place—in the experiments made by Government and others. Am I to hold, at this distance of time, that to be evidence to my mind of a process being adopted which just exhausted the plenum; which process when adopted in the course which the plaintiff has pointed out, results in this, that the stive is carried off dry, so that the moist air, being drawn up with the stive, and the air being blown off afterwards, the stive falls down, and is preserved in a dry state? The thing is kept in one continuous current, just exactly an equable current, which is all that is required, and the adjustment is complete and perfect. Now, as to adjustment, it was connected with machinery, and the machinery, of course, could by any contrivance of it make the thing go faster or slower, and some contrivances seem to have been adopted for that purpose; but these contrivances resulted in the state of things I have described.

After commenting upon various passages of the evidence as to this Isleworth Mill, his Honour remarked:—

"Now, I do not forget, of course (I attended particularly to the evidence, and have attended particularly to the very able comments that evidence received from all the learned counsel engaged, and especially as regards this particular department of the evidence, Mr. Williams did it with remarkable ability and remarkable accuracy), one other point valuable to the defendant is brought out, which is this: that this apparatus, such as it was and such as I have described it now, and such as everybody now agrees it was (the model being in accordance with it), did so far satisfy Mr. Kidd, and he may have the benefit of the observation, that he applied the same apparatus to other portions of the mill, not only the one he first applied it to but to other portions. It is a just remark to make, that it cannot be wholly fruitless and wholly useless, because, of course, he would not go to the expense (for some expense must have been incurred in such alterations) of obviating the inconvenience which Mr. Westwood pointed out, if he did not find some benefit from it, he would not have done it. I do not say he did not find some benefit, but the question is whether he has anticipated the plaintiff's patent—whether, testing it as Sir Roundell Palmer wished me to test the case (and I believe it is a correct mode), if it had been done after the patent instead of before it would not have been an infringement? Well, in answer to that I say I apprehend it would not. You have only claimed the exhausting the plenum. All modes between the zero on one side and the vacuum on the other, we think ourselves at liberty to use. I apprehend that to be so according to the case of Bovill *v.* Keyworth; you have laid your mark there, and that is your boundary. The answer would be, such a scheme as this, which does not exhaust the plenum, would have been no infringement of the patent; and it is said, the exact test was applied which was suggested by Mr. Bovill about the plenum. That is far from satisfactory. It was suggested that candles were applied; and in one case one witness has said that the flame of the candle was sucked up the spout, which would seem to imply that which I said before, namely, that the operation of the exhaust would scarcely reach down to the bottom part, would scarcely be just. I say it is just possible that the action under favourable circumstances might take place. This is only a single occasion that is talked of, when the flame of this candle was sucked up the spout; it does not appear this was done as a scheme or device, that the thing was rightly done, or that this was its right action. There is some conflict of evidence about that. Some say that the candle was put there to obtain light; and others say the light was not wanted, that there were gas lamps there, and candles that were not used, and that therefore the candle was brought for this particular purpose. But, in opposition to all that, it appears to me that there may well be at times a current of air going up in the way I described. The hot air could be going up there, and under particularly favourable circumstances it may have been so far applied as to produce an upward current, although I very much doubt it. Depending on one witness's evidence, in answer to a single question, I do not think is very satisfactory; and I do not think a case of such importance should turn upon such testimony as that. You must look at the whole apparatus, and the whole apparatus seems to be as different a thing as can be conceived from the apparatus the plaintiff had in view for exhausting the plenum so as to give the right quantum of air, which would have to be applied to the particular purpose in question."

"Now, on this part of the case, I ought to remark that the witnesses for the plaintiff state very positively and clearly (those, at least, who were employed in Kidd's mill) that the dust was not removed, that the stive was not withdrawn, that the mill continued very nearly as dusty as it was before, and although some of these men are discharged workmen, they do not appear to me to be in a position as to which I can possibly refuse to receive their testimony. The difficulty the plaintiff is put to in a case of this kind of course, is enormous. He has got a patent now, which has been prolonged—the Privy Council have granted him a prolongation; it is now about eighteen years this patent has lasted. Witnesses are called to speak to events which took place nineteen years ago; and the only thing that can be done is, to obtain all the testimony you can collect, and between the two, I think the plaintiff and defendant have exhausted it on both sides.

"I think, therefore, I have no satisfactory evidence before me as regards this mill being an anticipation, or what was done by Mr. Mather at the mill being an anticipation, of the plaintiff's patent. Of course the plaintiff is entitled to the observation that this has been before the jury, and upon this point the jury seems to have found for the plaintiff. The learned Judge before whom it was tried certified—I do not repeat the exact words, but the substance—that he was not satisfied with this verdict, and not satisfied of the evidence being such as to. prove the anticipation. The Master of the Rolls, adopting that view, has directed a new trial, and the plaintiff is entitled to say there is a state of things in which at all events he has already obtained a verdict. I cannot say it would be right and proper for me, now that all the facts are before me, to re-open all the question again. There really is not a single fact in dispute—if there be any fact in dispute it would be the dispute of whether dust still remained—that might be said to be a fact still in dispute; but we have no dispute, looking at the nature of the apparatus, and looking at the fact of it existing only for a limited time; looking at the fact of a skilled engineer coming and saying, as he does, it is more beneficial than anything he ever saw before, and yet never recommending it to a single customer; when you look at the fact of there being subsequently an alteration by which one process is adopted, which is of the highest importance, placing the exhaust where it could be useful, I think, looking at all the circumstances, and every single fact before me—if I am wrong in my conclusions from the facts I can be corrected elsewhere—but, really, to try such a case upon such a state of facts which are not in dispute, would appear to me to be an idle process.

"Now, Mr. Williams, in part of his argument, put the matter in rather a striking way to me. I noticed it, but I do not think it is substantial. It is rather an objection to the patent itself, as not being a description of anything new, than anything else. He says it is supposed that at Isleworth those things are all going on very satisfactorily until Mr. Kidd is told there is something for removing the plenum. Now the fresh light is to burst upon you. There is no direction in the patent how the thing is to be distinctly accomplished—what tests you are to have. You have given to you certain vague tests yourself; you give the candle test and certain other vague tests on the subject; you say it is hot to your hand, and not in so nice a condition as it ought to be; and then it is supposed that a sudden burst of light breaks upon you as to the plenum. That sounds very well; but the answer is, that the Court of Queen's Bench has decided that this is a new invention and that it is sufficiently described. But there is a much better answer than any judgment of a court of law could be, and that is the state of the facts. It appears to me that at Isleworth mills they did use a process which seems certainly something like Mr. Bovill's invention in 1856—they did do that; and therefore the discovery of the plenum did certainly effect that which was found wanting before the time at which the discovery was made."

Some of these passages are instructive and some remarkable, and not the less so because it happened that on a subsequent occasion they were relied upon before the same learned Judge, by a miller to shew that he had not infringed, but were unavailing for that purpose. The remarks to the effect that Mr. Bovill had already obtained a verdict against the evidence as to this Isleworth mill, are certainly obscure, and the fact was just the contrary.

Knowing as we do the nature of the questions which the jury considered in Bovill *v.* Keyworth, and that in the evidence in the present case there was not a syllable said by any person to the effect that he was instructed by Mr. Bovill's specification, to do anything which he was previously unable to accomplish; that there was in fact no evidence whatever of the sufficiency of the specification, and waking to the boldness of the learned Judge in deciding that Mr. Mather, Mr. Kidd, and all the others, were so imbecile, as to go on for years working an exhaust with a fatal fault in the air pipe, it is refreshing to see how the difficulty is overcome that the specification did not supply the necessary instruction for avoiding the blunders committed at Isleworth.

"Then as regards the other case, as to which I heard a reply; that was the case of the Houghton mill. As regards the Houghton mill, it stands in a very peculiar position. Mr. Potto Brown was examined, and the only question asked him in cross-examination was, whether he did not say before the Privy Council, as he admits he did, and I have the evidence before me, 'My scheme is not at all the plaintiff's scheme.' In his evidence here he says something more: his explanation is that he does not employ a blast. That is a suggestion of the counsel; but I do not think it is a suggestion that was repeated by the witness. I know now exactly what Mr. Potto Brown's contrivance did consist of. It is odd that, if he did not invent that which he describes, it should have been so long before it was heard of, because he was with the plaintiff, and saw D'Arblay's mill, which the plaintiff saw. He says, 'D'Arblay's mill, in a great degree, suggested to my mind what I afterwards did. I took the suggestion from what was going on there.' He came over and he made this, which he afterwards describes as not being at all the same thing as the plaintiff's; and I think, when we look to see what it is, we shall find it was not. Then he says the apparatus was altered, but very little, at different times. He says, as far as regards the substance, there was in fact no substantial alteration at all, and the thing has been in the same state since, and is so now. He says, since 1858 I have shut up my mill, and have not allowed any one to come in except some friends of mine. I am very careful, and will not have anybody there. Of course it is not satisfactory to the Court to have evidence about a state of things when it is so difficult to get the proper evidence upon it, and when the result of that evidence is intended to overthrow a patent. If I had to rest upon Mr. Potto Brown alone, it would be very unsatisfactory in that state of things; but I have the evidence of people who worked in his mill, who describe what has happened; and Mr. Justice Willes, very properly in his observations on this part of the case, said, they described it correctly. The witness's name is Charles Austin; he describes the apparatus at page 85, and he says: "I recollect the arrangements of the machinery in the mill at Houghton—they were as follows: wood spouts were connected with the side of the millstone cases, and these led into a horizontal wood trunk, which trunk ran along the floor, at the back of the range of the millstones,' (so far very like the Isleworth mills). 'From this horizontal trunk an upright spout went through the floor into a room above.' Now comes a very important point:—'The millstone case had holes cut all round the sides, and some of them had large holes as much as four inches in diameter. In the room above the stone-floor there was a fan worked by a strap running through an opening cut in the floor, the fan was open at the side or centre of the case, and the fan blades could be seen' (that is very much like the proceedings at Isleworth). 'Some hot air and dust used to come up the spout from the trunk and stone cases into this room, and afterwards ascended through a large hole into a room in the floor above it. I recollect occasionally seeing the men cleaning out the horizontal trunk in the ground floor, which they did with a hoe, and scraped out damp pasty flour' (similar to what they described at Glasgow as to the thing they called a 'monkey,' which they used to draw through it.) 'The dust and stive from the mill-stones used to blow out of the holes in the sides of the mill-stone cases, unless they were closed.' It is quite evident when you read the evidence, and Mr. Williams conceded it as far as the holes go; that, as far as the holes go, they were holes cut in the mill-stone cases. I do not understand how you can possibly get a plenum there at all. Mr. Robertson says you cannot get a plenum in the box. (I do not agree with him there), unless it is hermetically sealed; but I apprehend there may be a pressure of air, driving in other air occasionally, which is called a sort of muffle,—like the first attempt at the screw. It was done like a windmill, with the four sails, and it was found that a kind of muffle took place, by the accumulation of the water at the different points of the screw, and fish tails were afterwards adopted, when it was found that that muffle could not be remedied.

"There is this fact about the artificial blast; that when the holes are open, out blows the stive. That corroborates what I said before about the blast that takes place in common grinding. He says: "I have often seen this in the Houghton mill, as it made more stive and dust in the stone floor; the stive room in which the fan was placed was not an airtight room, there were holes in the floor through which the strap passed for driving the fans, and there was a window in the room, and the boards were not jointed airtight. The lower floor of the mill was not airtight; it was not very dusty, but still there was some stive coming down the meal spouts. I have seen the City mills, where there is no stive and dust, in the spout floor, and the said floor is in quite a different condition to that of the said Houghton mill spout floor.' Then he says he went again in 1866, and found considerable change in the working, that it was quite clear, although the stones were not grinding so much as they did formerly. 'And I found the stive rooms very different to what they were before; there was no wet yeast, or stinking flour as formerly, and gauges had been affixed to each pipe. The curtain in the upper room was not being used, but was drawn aside and hung in a bundle,'—ond so on. Then he describes exactly what happened at Houghton. As soon as the imperfections were discovered in these attempts and contrivances, the thing being a failure, seems to have been taken up, and something similar either exactly like the plaintiff's, or something very like the plainsiff's, to have been obtained.

"Now I think it will be only fair to read Mr. Potto Brown's deposition. Mr. Potto Brown tells you what he did in this way. He shews what directions he gave, and what additions he made:—'The new machinery consists of wide boxes or tubes, connecting a fan with the stone cases, which draws the hot air, and stive, and damp from the stone cases. The hot air, and stive, and dust were thus carried into two chambers, one above the other, the fan being in the lower chamber of the two. The upper chamber was divided by a large loose curtain, made of strainering, which is a porous material, attached to the ceiling of the room, and on one side of the room, and was made to open on one side and the bottom; the curtain entirely filled the aperture. The object of its not being attached to all four sides of the room was to clean out the room. The air which was drawn up by the fan escaped through the curtain into the other part of the upper chamber, which part of the chamber communicated with the open air by means of a large cylinder covered with a cowl, the air escaping through the curtain the stive remained in the inside. The curtain was not always used; it was not used in damp weather. In dry weather it was entirely closed; the object of the curtain was to strain the air, and so preventing the stive escaping from the mill, had it effected that object. After these alterations were completed the mill was in full work with the additional machinery, and was accessible to any one who desired to see it, and it was seen by a great many people. My workmen understood the use of the new machinery perfectly well; any one could see my mill and the machinery, up to about 1858, when the plaintiff commenced a suit against me. Since that time it has not been open except to our friends.' Then he says: 'The plaintiff has not proceeded in his suit against me.'

"Then John Clark gives evidence, and he says: 'I built some blowers to draw the air from the stone cases; by blowers, I mean a fan, and the fan was connected with the millstone cases by a long spout, from which long spout ran tributary spouts to the millstone cases.' Then he constructed a chamber, and a partition in the upper chamber. He describes all this, but does not describe that important part which is the part I have mentioned before, namely, the holes all round the box. Mr. Williams then said that would only make the room a part of the machinery. I apprehend the whole effect of the plaintiff's arrangement is this—accumulation of air in a confined space by means of a blast driven into it, and then we get a delicate arrangement, delicate in one sense, but not delicate in the other, an arrangement by which you shall simply throw off that which will not produce a draught, by means of the exhaustion, but simply to take off that muffle which occasions inconvenience and cause the stive to be blown out."

Enough has been extracted from the judgment to shew how the evidence of prior use was disposed of, and it needs only to be added that the decree was an injunction against Mr. Crate, restraining him from further infringing the patent, and ordering him to pay the cost of this suit as between solicitor and client.

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IT is a fact well-known to artists, that the splendidly bright colour of vermilion (cinnabar, sulphide of mercury) has a tendency, especially if it has been mixed with white lead, to become blackish brown and very dark coloured in a comparatively short time. This tendency of the vermilion is altogether obviated if, previous to being mixed with oil, it is thoroughly mingled with about one-eighth of its weight of flower of sulphur.

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# MIDDLESBOROUGH IRON AND STEEL INSTITUTE.

## ON THE MANUFACTURE OF RAILS.

By MR. WILLIAMS.

The writer said he proposed to consider, from the standpoint of a railmaker, the several kinds of rails in use, the merits and demerits of each, together with the processes of manufacture generally followed. It was too much the habit to assume that there was antagonism between those who make rails and those who use them; and that the former desire only to make cheap rails, however bad, and that the latter interpose difficulties and onerous stipulations without reasonable cause. He believed that view to be entirely incorrect; that, on the contrary, the great majority of engineers and ironmakers alike were, in their several ways, striving after the same end, namely rails of high quality and at the lowest price possible.

The rails of to-day were of two distinct kinds; those made from ingots, and those built up; and he admitted that the question of cost and possible supply not considered, ingot-made rails were the best. It was incorrect to describe the two kinds as steel and iron rails, because the Bessemer rails now making have a percentage of carbon much lower than that of steel proper, as they used to know it. Besides, as far as he knew, it was impossible to define where iron ended and steel began. It would be as well, therefore, to call the two divisions ingot rails and piled rails. He had come to the conclusion unwillingly that they would not succeed in producing puddled workable and welded solid blooms; and, as far as their present knowledge extended, ingots, cheap enough to make rails on a considerable scale, were only to be obtained by the Bessemer process. Whether or not the Siemens-Marten process could compete in point of cheapness of production with the Bessemer process, was as yet unproved. It was sufficient to know that both could without doubt produce ingots that rolled into rails without much difficulty; and that such rails, being free from the possibility of lamination, must be more enduring than built-up or piled rails, however carefully made. If the phosphorus difficulty could be got over—and he thought it could—and the cheap pigs of the Cleveland district were available for the Bessemer process, there would be so great a reduction of cost that ingot rails would be almost as cheap as piled rails, and the latter must at once give way; but there was not at present any good ground for expecting that such a change was near. The removal in February next of the bulk of the present Bessemer royalty charge would no doubt reduce the selling price of ingot rails; but he was mistaken if after all, they could be produced so as to be sold within 40s. or 50s. per cent of the average selling price of good piled rails, the life of which in the ordinary operations of a heavily worked railway would be about fifteen years. For very severely worked places ingot rails at almost any moderate extra price were of course the best. Strenuous efforts had been made by nearly all the great ironmakers to produce steel topped rails, which it was hoped would be made much more lasting than the usual piled iron rails and less costly than ingot rails. Puddled steel seemed to offer a cheap and good material for this; and after some difficulty to begin with, it was produced of very uniform quality. It was no doubt a material capable of resisting well the wear and tear of railway stock; but it could scarcely be welded at all; and as it could not be obtained in solid blooms for rail sizes the system failed, and had been abandoned, in this country at least, entirely. That Bessemer steel slabs could, by great care and skill, be so fastened to iron as to make rails, was proved by the instance of the rails supplied to the Edinburgh and Glasgow Railway and to the Swedish Government. He however, did not expect to find such rails come into general use, because of the difficulty of welding on the steel slab, which is not much, if at all, less than puddled steel. So far as he could see, the only choice lay between the ingot and the piled rail; and in the uncertainty as to the Siemens-Marten process, it might be assumed that the Bessemer process would supply the former.

He did not advocate the discontinuance of testing rails. But to meet the severe tests it was absolutely necessary to use fibrous iron, and not to beat it too much. He had thought and experimented much upon the subject, and was satisfied that fibrous nature and weldability did not go together; and that only well piled crystalline iron welded easily, and therefore, with moderate certainty. It was undesirable, he thought, to use rail piles of great sectional area, which are less likely to be heated equally at the centre, than the small piles of a quarter of a century ago. The two great rail-producing districts of this country were Wales and the North of England; and each had a system of working different from the other. The Welsh system had the merit of more work in the iron—that is, greater consolidation—than is obtained by the North of England system. That was a doubtful advantage, if it was really, as he believed, that the iron for rails was, as a rule, too much worked; while it had the demerit of having many through welds on the heads of the rails. The North of England system produced hard crystalline heads with the fewest possible welds; and when the iron of the district was not too much worked, and thus made fibrous, it was of the most weldable character, though somewhat brittle. Such iron, it seemed to him, was likely to produce enduring rails; and he firmly believed that with proper attention piled rails could and would for a long time yet be made from it, as enduring and capable of competing successfully with good ingot rails produced by the Bessemer process.

## SIEMENS' REGENERATIVE FURNACES.

By Mr. J. T. Smith.

Although, the writer said, this subject has been brought before various societies since 1862 by some of the most eminent men of the day, and for many years had been in extensive and successful operation in various processes connected with manufactures, both at home and abroad, it had, with very few exceptions, not been adopted in the iron and steel works of Great Britain. It was possible, however, that in a few years those districts which contained large quantities of inferior coal or fine slack, without sufficient bituminous principle to make it available for cooking purposes, would find that they possessed, by means of the above invention, the means of supplying their requirements from such sources. While in this country it was probable that coal would exclusively be used to produce the gaseous fuel required for the regenerative furnaces, in France, Belgium, and Spain they merely used wood; in Germany lignite, and in Italy peat. It was believed that the first idea of storing waste heat to be used at intervals was due to Dr. Stirling, of Dundee, who, in 1817, patented the regenerator or heat accumulator, and subsequently applied it to his caloric engine. Captain Ericsson, in 1851, also used a kind of regenerator to his air engine; but Siemens had previously, in the years 1847-8-9, taken out patents for his regenerative steam engine and condenser. None of these inventions ever came into extensive practice, and not till 1862 did the discovery really assume a shape which was at all attractive. The invention might be generally described as requiring a producer—for the volatilisation of coal, wood, peat, and such like products into gases—which might be erected at any practicable distance from the furnaces to which they were to be applied; while a regenerator, divided into four compartments filled with loose fire-bricks, had to be placed under the furnaces. These regenerators were simply fire-brick chambers divided into four compartments, one on each side for the passage of gas, and two in the centre for air, with generally five ports at each end communicating with the furnaces above. The chambers were filled with fire-bricks placed in a chequered manner, and while the upper portion had to be of the best quality, those beneath would answer if they were of the most inferior description. The chemical action which took place in the producers was described by Mr. Siemens in his lecture before the Chemical Society as follows: "Air is admitted at the grate, and, as it rises slowly through the ignited mass, the carbonic acid first formed by the combination of the oxygen with the carbon of the fuel takes up an additional equivalent of carbon forming carbonic oxide, which, diluted by the inert nitrogen of the air, and by a little unreduced carbonic acid, and mixed with the gases and vapours distilled from the raw fuel during its gradual descent towards the grate, is led off by the gas tubes to the furnaces." The temperature of the gas at the junction of the upcasts with the tubes was from 1,250 to 1,300 degrees Fahrenheit, a rather higher point than had yet been noticed. Before it had travelled 200 ft. in the tube, with an external atmosphere of 60 degrees, the temperature was reduced to about 130 degrees. He had himself been unable to ascertain the exact quantity of heat lost by radiation in the interval, but the experiments, although not complete, were sufficient to show that the quantity was so small that at present he could see no way of economically applying it. This lowering of the temperature and condensation of the gases was of advantage in many respects. The gas being heavier, caused, in its transit through the tubes and the various downcasts, a syphon action; and thus not only drew the gas from the producers to the furnaces, but, by keeping up a slight outward pressure, prevented the admission of air through any crevice in the tubes or the expansion boxes. It also deposited the tar from the coals into a series of wells beneath; while the water in the fuel was also condensed, and thus prevented from causing a waste of metal by introducing a too great supply of oxygen into the furnaces. After noticing more in detail the application and effect of the gases, Mr. Smith added that for many months each producer at Barrow had volatilised 3 tons of coal per 24 hours, and that the greatest economy effected was when the consumption had not exceeded 50 cwt. Estimating the weight of one cubic foot of gas at the ordinary temperature of thin air to be ·075 lb., the volume of carbonic oxide, hydro-carbon, and hydrogen from one ton of coal would be about 53,000 ft.; and the volume of nitrogen about 122,000 ft., or making together a total of 175,000 ft. The consumption of coal in the producers at Barrow being 500 tons per week, it gave an amount of gas passing through the tubes at the rate of 6½ ft. per second, of 87,000,000 cubic feet; or through the various furnaces, adding the quantity of air there admitted, of 6,600 tons. The saving of fuel by this process at Barrow was, over a period of two years, no less than 44 per cent.; but the actual money saving, by the use of a particular kind of coal, had been more than one-half. The yield of the gas furnaces, taken over the same period, showed a saving of 21 per cent. as compared with the work at the firing furnaces, and the amount of the repairs was just two-thirds of the old cost. In these three particulars was undoubtedly to be found the chief economy; but the adoption of the system enabled them to preserve greater cleanliness and order in their works, and an entire absence of smoke met a difficulty which in the neighbourhood of large towns was every year becoming a greater grievance. There was, he admitted, a slightly increased outlay on the plant; but taking into consideration the increased capabilities as to quantity, it would be found to represent the difference in cost between the two systems.

## ON A NEW PROCESS FOR REMOVING SILICON FROM IRON.

By Mr. J. Palmer Budd.

In the Welsh ironworks, the pig iron is principally white. The whole of the forge cinder made is put on the blast furnaces, and cinder in large quantities is purchased in addition from the tin-plate and other neighbouring forges. A large admixture of Lancashire and Cumberland and other hematite ores is put on the furnaces as a corrective. The furnaces are driven hard, and the white is of course inclined to be sulphury. The plan of working is to refine before puddling, from a half to a third of the white in refineries placed before the blast furnaces, running the iron into them. The yield of these fineries from molten iron is about 23 cwt. of pig or cast iron to the ton of refined metal; the consumption of coke is 5 or 6 cwt. to the ton; and the total expense of the refinery process from 10s. to 15s. a ton. In some works the puddling furnaces have one-half white pig and one-half refined iron; in others, the proportion is one-third refined metal, one-third white pig, and one-third mine pig, made without cinder from argillaceous mine and hematite ores. Soft Lancashire ore is freely allowed for fettling the puddling furnaces.

The popular notion is, that the white iron is decarbonised in the refinery process, and freed from sulphur and phosphorus. Messrs. Crace Calvert and R. Johnson, Dr. Percy, and other authorities, have shown conclusively that this popular notion is unfounded. They have proved that all cast iron contains a notable proportion of silicon, varying from 1 to 6 per cent (the greyer the iron the greater the proportion of silicon), which is reduced in the blast furnace, and combined with the iron from its earthy base, silica. It is silicon which imparts its casting property to pig iron; when, removed cast iron is only semi-fluid, although it may retain all or nearly all its carbon. From its greater affinity for oxygen than carbon, silicon protects the carbon in pig iron from the action of oxygen, even when it is present in the small proportion of 1-500th per cent, no carbon is burnt off. Silicon is, in many of its properties, very analogous to carbon; and the refining process, instead of being called a decarbonising, might be better described as a desiliconising of the iron. Now, the process he had invented desiliconised the iron as tapped from the blast furnace without wasting the iron, and without any extra expense whatever beyond the usual cost of the pig; nay more, it was more economical to make than pig iron. The process must therefore revolutionise the present practice in the iron trade. His usual mode of proceeding was to place a series of iron moulds similar to those used before a refinery, as near as convenient to the tap hole of the blast furnace. He made a paste by moistening with water soft hematite ore, which, if gritty, is previously ground, and he threw a bucket-full, containing about 60lb., into the mould in a semi-liquid state, and spread it evenly on the bottom and sides. The mould being quite hot from the previous cast, dries the paste, which adheres to the bottom. He then taps as much iron as is required from the blast furnace, and allows it to run over and fill the moulds to the depth of three and a half to four inches. A great ebullition takes place; jets of flame of a peculiar white colour burn on the surface, which he assumed to be combustion of silicon in the oxygen liberated from the hematite. It was proved by repeated analysis that whilst the silicon was 1·00 per cent. in the white cast iron, it is reduced by this simple process to 0·200 or 0·300 per cent., or from 1 per cent. to 1-500th. A cinder is thrown up containing silicon, some phosphorus, and sulphur. The carbon is hardly at all removed. The appearance of the iron after the process is that of refined metal. For want of sufficient upward impulsive force a good deal of the scoriæ, although chemically separated in the process from the iron is not removed from it mechanically, but is mixed with the refined metal; and, on remelting in puddling furnaces, forms a protecting slag.

The cost of the process is *nil*, as the iron contained in the hematite is reduced, and adheres as cast iron to the bottom of the iron in the mould. There is no sand or coke dust used: and the refined iron goes clean into the puddling furnaces. The yield in puddling is, that of refined iron, about 21 cwt. to the ton of puddling bars. The puddlers like to have one or two pigs of white with the metal so refined, as they say it works more liquory—showing that when the silicon remaining is only 0·200 or 0·300 per cent., the charge does not possess the necessary fluidity. The puddling furnace keeps longer in repair, no other fettling is used, and hammer slag and the former allowance of shearings to make scrap balls has been discontinued. The men do more regular work, and, like the refined iron, while the yields are larger. The puddled iron is of an improved quality, and much liked in the rail mills. The second process was the same as the first, only that he mixed two-fifths by weight and half by bulk of nitrate of soda with the hematite ore, which is formed into a paste, and applied in the same way. With this mixture the ebullition is greater; the flame is of a yellowish colour, showing the ignition of some of the soda. The cinder is thrown up and out of the iron, over which it forms a crust, which can be separated when cold. The iron has a cellular and honey-combed fracture like metal much over-blown. The scoriæ contains sulphur, phosphorus, silica, and soda. The iron works drier and cleaner, and to a better yield than that made by process number one, but should have about one-third of grey pig added to make a very clean and rough iron. The only cost of the process is the nitrate, which in the proportion named comes to about 4s. a ton at its present high price. The saving by the process was very considerable, and it was not confined to white iron, though it was then most efficacious. In conclusion, he expressed the pleasure he felt in visiting that neighbourhood, and paid a high compliment to the ironmasters of the district for the skill and enterprise with which they had developed the resources.

## BRITISH ASSOCIATION.

### THE RESISTANCE OF VESSELS.

(*Continued from page* 233).

### Propulsion.

We do not consider it advisable in the present report to enter into the question of propellers, except so far as may be necessary to the choice of experiments.

All propellers except sails, tow ropes, and punt poles, do their work by the reaction arising from their driving a stream of water in the opposite direction to the ship's motion, or to their stopping or reversing streams already flowing in that direction. This is the case with oars, paddle wheels, screws, and water jets alike. But while they have one principal action in common, they are only different in their detailed effect upon the currents and waves which accompany the ship, and in the way in which these currents and waves re-act upon them. Thus, the oars of a row boat send two streams aft, at such a distance from the sides of the boat as to interfere very little with, and to be very little interfered with by, the waves and eddies due to the boat's motion. In the screw propeller, on the other hand, a large proportion of the wake current is either stopped or reversed by the action of the screw, which also interferes with, and is itself re-acted upon by, the wave of replacement These interferences are so large in amount as not unfrequently to mask the whole of the *slip*, from the re-action of which the propulsion is obtained, giving rise to the phenomenon of *apparent negative slip*. For a theoretical account of what is supposed to take place under these circumstances, we refer to the following papers in the "Transactions of the Institution of Naval Architects," and the discussions which took place upon them:—Rankine, "On the Mechanical Principles of the action of Propellers;" Froude, Note on the above paper, vol. vi. for 1865, p, 13, *et seq.*; Reed, "On cases of Apparent Negative Slip," vol. vii. for 1866, p. 114, *et seq.*; Rankine, "On Apparent Negative Slip;" Froude—On the same; Rigg, "On the relations of the Screw to its Reverse Currents," vol. viii. for 1867, p, 68, *et seq.*; Rigg, "On the Reverse Currents and Slip of Screw Propellers," vol. ix., for 1868, p. 184. See also Bourne "On the Screw Propeller," second edition, chapter iii., and Rankine, "Shipbuilding: Theoretical and Practical," pp. 88, 89, and pp. 247, 259.

We consider it to be beyond doubt that the theoretical investigations of this part of the subject have been extended in advance of the point at which fresh experimental foundations ought to be laid for them.

### Former Experiments of Resistance.

The first important experiments were those made by Bossut, Condorcet, and D'Alembert, by direction of Turgot. The results were published as a separate work in 1777, and a very full abstract of them is given by Bossut in his "Hydrodynamique." The chief results are summarised by Bossut as follows:—That the resistance of the same body at different speeds, whatever be its shape, varies very nearly as the square of the speed. That the direct head resistance of a plane surface is sensibly proportional, at the same speed, to the area of the surface. That the measure of the direct resistance of a plane surface is the weight of a fluid column which has that surface for its base, and whose height is that due to the velocity. That the resistance to oblique motion, other things being alike, does not diminish by a law at all approaching that of the squares of the sines of angles of incidence, so that for sharp entrances, at least, the former theory must be completely abandoned.

Mr. Scott Russell has remarked that between certain limits the observed resistances of wedge bows could be represented with a close degree of approximation by a formula of the form,

$$R = K\left(\frac{n}{2\pi - \epsilon}\right)^2$$

where K is a constant, $\pi$ stands for 180°, and $\epsilon$ is the angle of the wedge, which is supposed to be of not less than 12°, and not more than 144°. See his "Naval Architecture," page 168, and "Transactions of the Institution of Civil Engineers," vol. xxiii,, page 346.

The next experiments of importance are those of Chapman, published in his "Architectura Navalis Mercatoria." The result of those has already been mentioned. He performed some fresh experiments at Carlscrona, in 1795, which seemed to lead to somewhat different conclusions. See "Inman's translation of Chapman," page 41 and page 257.

We then come to Beaufoy's experiments in the Greenland Dock from 1794-1798. This enormous series of experiments can only be regarded as establishing very few facts, among which we may mention,—That the resistance to oblique surfaces does not vary as the sine squared of the angle of incidence. That for unfair bodies, such as he experimented upon, the resistance increases faster than the square of the velocity. That increase of length, within certain limits, has a tendency to decrease resistance. That friction of the wetted surface enters largely into the resistance. That friction of the wetted surface appeared to increase in a ratio somewhat less than that of the velocity squared—between $v^{1\cdot7}$ and $v^{1\cdot8}$. He also arrived at the conclusion that bodies immersed to a depth of 6ft. experience less resistance than at the surface, but in the case of an iron plane towed flatwise, he found that the resistance increased with the depression. The whole of these experiments lose much of their value from having been tried on small models, and on bodies which are not ship-shape.

The "Philosophical Transactions," for 1828, contain an account of experiments performed by Mr. James Walker in the East India Import Dock. A bluff bowed boat was towed across the dock by a rope and winch, worked by labourers, the rope being fast to a spring weighing machine on board the boat. The boats tried were of somewhat bluff form, and it was found that the resistance varied only roughly as the velocity squared, increasing faster than that at high speeds. The drawings of the boats are not given with all the detail that could be desired, nor is the condition of their surface minutely described. But the experiment was in the right direction, being upon actual boats meant for use, and of a size far exceeding the models of previous experimenters.

Some experiments by Mr. Colthurst both on the forms of floating bodies as affecting their resistance to motion, and on the friction of wetted surfaces, are given at p. 339 of vol. xxiii. of the Institution of Civil Engineer's "Transactions." We also refer to the report of the committee appointed by the British Association upon the comparative resistance of bodies wholly and partially immersed (B.A. Reports, vol. for 1866, p. 148). That committee decided to print the observed facts without any deductions. It is not necessary to the purposes of this report that we should discuss them. We have already alluded to the difficulty which they indicate as being felt, with respect to the way in which the water of replacement flows in at the stern.

We will next refer to the experiments of Captain Bourgois, which were begun at Indret, in 1844. He first had several boats from 22ft. to 25ft. long towed by the *Pelican* steamer, then under his orders, and later a small merchant schooner of a little over 60ft. long—and afterwards the *Fabert*, a brig 98ft long. These vessels were simply towed, and their actual resistances measured with a traction dynamometer. Similar experiments have also been tried in France with the screw steamer *Sphinx*, 109ft. long; with the screw despatch boat *Marceau*, 131ft. long (with its screw upon deck), and with the 74-gun ship *Duperré*, 180ft. long, built by Sané. Probably, nothing could be better than the experiments thus made, and it is from these that M. Bourgois has derived the coefficients of the formulæ which he has given. But, unfortunately, the particulars of the ships experimented upon are not given in great detail, nor are their drawings published. The only particulars given are the length and breadth on the water-line, the draught, and the area of midship section immersed; but without wet surface; or even displacement.

M. Bourgois's memoir has no date; but it is evidently later than 1853, since he mentions that as the date of an experiment. It also contains some results of trials of propellers set to work against a dynamometer with the vessel made fast, and some trials depending upon the measurement of the power exerted by the engine. But we do not propose to discuss the trials on steamship performance. Not only is this the work of another commitiee, but, inasmuch as they introduce the uncertain effects of the engines and propeller, they fail to give any accurate account of the resistance of the water.

In the earlier history of the subject, it was supposed that models would most aptly represent ships at the same speed both for the ship and the model. The experiments at the East India Import Dock, 1827 or 1828, seem to show a dissatisfaction with the results of small models, and some time later, M. Réech, the Director of the Ecole d'Application due Génie Maritime in France, pointed out that models of different sizes, intended for comparison, should be made to move at velocities varying as the square roots of their lineal dimensions. In this case the actual resistance would vary as the cube of the lineal dimension. This would follow from the theory of the resistance of submerged bodies, on the supposition that the resistance varies as the square of the speed. If, again, we consider Mr. Scott Russell's theory of the length of ships—that their extreme speed should not exceed that of an oscillating wave, bearing a definite ratio of length to that of the ship, we arrive at the same conclusion, the length of the wave varying as the velocity squared.

### Proposed Experiments.

The experiments upon resistance which we consider most important to be made are these:—

That a ship of considerable size and fine form should be carefully selected; a screw steamship, with a screw capable of being lifted; with a clear deck, offering no unnecessary resistance to the air; and with little or no rigging. That her form should be carefully measured in dock (her lines taken off, as it is technically called), and sight marks carefully laid down, so as to ascertain whether she deforms in any way when afloat. That she should be towed at various speeds, from the slowest that can be rated to the fastest that can be obtained; and that the resistance should be ascertained by a traction dynamometer, self-recording. That the place selected for the experiments should be a deep inland water, free from groundswell, and such that the speed of the vessel can be observed from the land as well as from the vessel. The water also should be clear enough to admit of being seen through to a considerable depth. The place, if tidal at all, should be free from cross tides or irregular currents. These conditions, it is believed, may be found both in Norway and on the west coast of Scotland. Careful observations should also be made with a view to ascertain the direction and velocity of the local currents caused by the ship's motion. What these should be will demand careful consideration, having regard both to the ship and to the place selected, and to the *personnel* of the observers.

The same remarks will apply to the precautions necessary to prevent interference by the currents thrown back by the towing vessel or vessels, and to eliminate other sources of error. It is of especial importance that the ship which is being towed should be kept clear of the wake of the towing vessel or vessels. It might be necessary for this purpose to have two tug-boats with hawsers meeting at an angle in the form of the letter Y. It is desirable that these experiments should be performed with at least two vessels considerably differing both in size and in proportions, and, for each of them, with different conditions as regards smoothness of surface.

A third class of experiments should also be made to determine the rate of retardation of a vessel which has been made to attain a certain velocity, and then (the propelling power suddenly ceasing to act upon her) is allowed tó come gradually to rest through the resistance of water.

It would be desirable that the same vessels (and as nearly as possible under similar conditions of draught and trim), should be made use of for trials of propulsion, and that in these again a dynamometer should be interposed between the engine and the propeller, and that in this case also the local currents and waves due to the joint disturbance of ship and propeller should be observed.

We consider that experiments of the kinds which we have proposed have now become necessary, not only to the theory of resistance, but also to the practical calculations of the effect of steering and propelling apparatus, and incidentally to the design of these, and to the apportionment of engine-power and driving speed. Such experiments are quite beyond the means of anybody but the Government of a naval power in time of peace, possessing ships which must be exercised with their crews and staff of officers. There would of course be extra expense attending such trials; but this expense is in no way commensurate to that of building experimental vessels, or arriving tentatively at the suitable forms and positions for propellers. We therefore recommend, that the Council of the British Association should authorise a deputation to apply to the Admiralty to provide for such a set of experiments in the course of the summer of 1870: also that the Council should appoint a committee consisting of three members of the Association, to confer with officers of the Admiralty, respecting the detail of the experiments, and that the Admiralty should be requested to give an opportunity to the members of that committee of taking a share in the observations, in order that they may be enabled to make an independent report upon the results.

### Rolling of Ships.

#### *Stability and Free Oscillation.*

The statical stability of a ship in still water depends upon two equations and an inequality. Its weight must equal that of the fluid it displaces, or it will adjust itself by changing its water-line. This involves a first equation. The centre of gravity of the displaced water must be in the same vertical line with the centre of weights, or there will be a couple which will produce rotation; after which the ship will take up a fresh position. This involves a second equation. In case of a small angular displacement, the centre of gravity of the displaced water (or centre of buoyancy), must move out faster than the centre of weights; otherwise, on the slightest derangement, there will be an upsetting couple, that is to say, the equilibrium is unstable. This involves an inequality.

The arm of the couple is the horizontal distance between the centres of weight and buoyancy. The moment of the couple is the product of this into the weight, or, what is the same thing, the displacement of the ship. If the centre of buoyancy moves out faster than the centre of weight as the ship heels, there is a righting couple; if not, there is an upsetting couple, which tends to bring the ship to some new position of equilibrium.

If we consider a vessel having a plane of symmetry, like that in which the masts, stern-post, and keel of ordinary ships lie, and rolling transversely, we gain much in geometrical simplicity, and also in simplicity of language. We are enabled to deal with the mechanical questions by means of plane geometry, and we are still able to extend them when necessary, by the ordinary rules of the composition of motion. For this purpose we have only to consider the axis of motion as parallel to the plane of symmetry and to the water section. The statistical stability, as already remarked, is measured by the weight and buoyancy. But when these coincide in horizontal position, as they do when there is equilibrium, we are driven to some other measure in order to avoid indeterminateness at the limit. For this purpose we avail ourselves of the point at which the vertical line through the centre of buoyancy strikes the plane of symmetry, or middle line plane, as it is technically called. The limiting position of this intersection, when the angular deviation is indefinitely small, is called the metacentre. This metacentre is the critical point below which, if the centre of weight be kept, there will be stable equilibrium.

It is shown in books on hydrostatics that if a floating body receive a small inclination, the two water sections intersect in a line passing through the centre of gravity of each, and also that the line, passing through two successive centres of buoyancy, tends to parallelism with the water section. It follows that the stability of a ship, statically considered, may be measured by the statical stability of a solid, whose centre of gravity coincides with that of the ship, but whose surface, instead of floating in water, rests on a horizontal table. This representative surface is the surface formed by the centres of buoyancy of the ship at different inclinations. The metacentre of the ship is then the centre of greatest or of least curvature of this representative surface, called the surface of buoyancy, according to whether we consider transverse rolling or longitudinal pitching.

When we pass from statics to dynamics, the righting or upsetting force simply represents an acceleration. But if the ship be considered as concentrated at its centre of gravity (in disregard of the actual distribution of weights in respect of inertia), the same geometrical considerations hold, and the space through which the centre of gravity rises or falls as the surface of buoyancy rolls is called the measure of dynamical stability.* It is simply proportional to the integral of the statical stability taken with reference to the angle of inclination. Its product into the displacement gives the mechanical work required to heel the ship, considered as concentrated at its centre of gravity, to a given angle. An example of its use is in the solution of the problem of finding how much a ship would lie over to a sudden gust, strong enough, if it came on gradually, to heel the ship to a given angle. The rough solution is that she would lie over to double the angle of the statical stability, and this remark is of importance in judging of the safe limits of a ship's stability. This solution, it is to be observed, takes no account of the moment of inertia of the ship about its centre of gravity, and very little account of external form.

Experiment and theory both go to prove that the time in which a ship performs a complete double oscillation varies but very little, whether the amplitude of the oscillation be small or large. Hence every ship has its equivalent pendulum. If $k$ be the radius of gyration of the ship, $\mu$ the distance between the metacentre and the centre of gravity, the length of the equivalent pendulum is

$$\frac{k^2}{\mu}$$

the periodic time† is

$$2\frac{\pi k}{\sqrt{g\mu}}$$

and the greatest angular velocity is

$$\frac{2\sqrt{g\mu}}{k}\sin\tfrac{1}{2}\theta,$$

where $\theta$ is the amplitude, or departure from the vertical; but the approximation in this last formula is much less than in that for the time.

Dupin has shown that the free rolling of a ship, regarded without reference to the disturbance or resistance of the water, is analogous to the free rolling and sliding on a smooth plane of the surface, which is the envelope of its planes of flotation; the centre of gravity, the upward pressure of the fluid, and the moment of inertia being supposed to be unaltered. But, although this statement reads simply enough, the expression for the time and the period, which result from it, are exceedingly complex. An investigation of it, subject to the sole restriction that the transverse section of the surface enveloping the planes of flotation shall be circular, has been given by Canon Moseley, in the "Philosophical Transactions" for 1850, p. 626, and is reprinted in his "Engineering and Architecture." The resulting expressions depends upon a hyper-elliptic integral. But we are without evidence as to how far the restriction is fulfilled by ordinary ships; and we do not find reason for supposing that the variation of the radius of curvature, which is thus taken as constant, has ever been practically investigated. There is, however, no difficulty in extending the formula to the general case; but it does not appear that the integration can be effected without introducing restrictions. At any rate the value of the integral has not yet been traced, except for small oscillations, when it reduces to the one previously given. There is a reduction in some particular cases,‡ and notably in the case of iso-

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* The true dynamical stability is the actual work done in heeling. But the words are ordinarily used in the sense stated in the text.

† The time here used is that of a double oscillation; *i.e.*, the time which elapses between the bob of the pendulum passing the lowest point twice in the same direction. There is very often confusion between double and single oscillations, both with analysts and in the records of experiments.

‡ Let $k$ be the radius of gyration, the height of the $\lambda$ metacentre above the centre of of buoyancy, $H_1$ and $H_2$ the *depths* of the centres of gravity and buoyancy, all taken for the upright position. Also let $\theta$ be the inclination, and $\theta_1$ the extreme, and $\rho$ the *height* of the centre of curvature *above* the actual plane of flotation. Then Canon Moseley's formula gives for the periodic time of the double oscillation:—

$$\sqrt{\frac{2}{g}}\int_{-\theta^1}^{+\theta^1} d\theta \sqrt{\frac{k + (H_1 + \rho)^2 \sin^2\theta}{\left\{H^1 - H^2 + \frac{1}{2}\lambda(\cos\theta + \cos\theta_1)\right\}(\cos\theta - \cos\theta_1)}}$$

It will be observed that $(H_1 + \rho)\sin\theta$ is nothing but the horizontal distance between the centre of gravity of the ship, and that of the plane of flotation; or, in other words, the perpendicular from the centre of gravity on the normal to the flotation envelope. It seems, at the same time, simpler and more general to use this which we may call $\nu$, instead of considering the curvature. We thus get for the periodic time,

$$\sqrt{\frac{2}{g}}\int_{-\theta_1}^{+\theta_1} d\theta \sqrt{\frac{k^2 + \nu^2}{\left\{H_1 - H^2 + \frac{1}{2}\lambda(\cos\theta + \cos\theta_1)\right\}\left\{\cos\theta - \cos\theta\right\}}}$$

Now, if $\nu$ be constant, that is to say, if the flotation envelope be the involute of a circle described round the centre of gravity of the ship, this reduces to a complete elliptic integral of the first kind; but the solution is not mechanical unless $\nu = H$ or the flotation envelope reduces to a point. When, moreover, the centres of gravity and buoyancy coincide, $H_1 - H_2$ vanishes, and the integral may be at once transformed to its regular expression by writing $\sin\theta = \theta^1 \sin\phi$. We then get for the periodic time

$$4\frac{\sqrt{k^2 + \nu^2}}{\sqrt{\lambda g}}\int_0^{\frac{1}{2}\pi}\frac{d\phi}{\sqrt{1 - \sin^2\theta_1\sin^2\phi}}$$

The time at any moment is got by integrating from $-\theta_1$ to any value of $\theta$ instead of to $+\theta^1$.—C.W.M.

chronous ships. Professor Rankine[*] has shown that the condition of isochronism is that the curve of buoyancy should be the second involute of a circle described about the centre of gravity.

It does not appear that the arithmetical consequences of the variation of the law connecting time and angular velocity in unresisted free rolling have ever been worked out. It would be a very laborious business, and we shall see by-and by that it is not the chief problem.

Reverting to the approximate formulæ for small oscillations,

$$\text{periodic time} = 2\frac{\pi k}{\sqrt{g \mu}} = 2t, \text{ suppose;}$$

$$\text{greatest angular velocity} = \frac{2\sqrt{q \mu}}{k} \sin \tfrac{1}{2}\theta,$$

$$= \frac{2\pi}{t} \sin \tfrac{1}{2}\theta;$$

we see that the periodic time of the oscillation varies directly as the radius of gyration, and inversely as the square root of the metacentre height. This teaches us how to regulate the periodic time of a ship, either in settling her design or in the distribution of her weights. We see, for instance, that a vessel with a rising floor and flaring sides tends to quick rolling, by having a high metacentre; that a cargo of railway bars has the same effect, by bringing down the centre of gravity; and that running in the guns and sending down the masts has a similar tendency, by decreasing the radius of gyration. The expression for the greatest angular velocity has been sometimes interpreted as indicating that quick rollers roll through large angles. The fact appears to be experimentally true, but its inference from this formula involves reasoning in a circle. The formula only shows that for the same amplitude the greatest angular velocity varies inversely as the time; but this tells us nothing about the amplitude, while the formula itself is obtained on the supposition that the amplitude is small.

The position of the ship's centre of gravity and the length of the radius of gyration cannot, practically, be obtained by calculation. The centre of gravity is generally found by shifting some known weights through known distances, and observing the angular motion. The displacement and metacentre are of course known by calculation, and the problem is then the same as if the ship were suspended from her metacentre.[†] The radius of gyration is found by observing the time of a small oscillation in still water, and then eliminating the effect of resistance.[‡]

As the metacentre depends upon the moment of inertia of the plane of flotation, it is different for pitching to what it is for rolling, and so for any intermediate position.[§] Practically, the metacentre for rolling varies from 0 to 20ft. (as an extreme limit), above the water line, while that for pitching is from 70 to 400 or more feet high. The moment of inertia of the ship also varies greatly with the direction of the axis about which it is taken.

### Free Rolling in a Resisting Medium.

The experiments of Messrs. Fincham and Rawson, undertaken at the suggestion of Canon Moseley,[||] led to the conclusion that, for vessels of semicircular section in which the disturbance of water is the least possible, the dynamical stability, found by experiment, differed very little from that derived from the rise and fall of the centre of gravity; but in the case of a model of triangular section, the stability found by experiment was in defect. In the semicircular model the extreme inclination produced by the sudden application of the force was, with a fair degree of approximation, double that due to its statical effect. With the triangular model the extreme was less than double the statical inclination. This is nothing more than might be expected from the disturbance of the water which would be set up by the angular model, and which would, of course, take up part of the work. But this experimental confirmation of theory is highly satisfactory; and however we may now look back upon the matter, it is really upon these experiments that the confirmation of our theories rests.

In a resisting medium, the amplitude of the oscillations is very quickly effected, but the periodic time undergoes very slight change. But the period is altered to a slight extent. On this subject we refer, firstly, to the account given by Poisson, Stokes, and other writers on mechanics, concerning the oscillation of a pendulum in air; secondly, to Mr. Fronde's experiments[¶] on a pendulum oscillating in water; and, thirdly, to Professor Rankine's Paper on Keel-resistance[*] in which the measure of diminution is given on a certain hypothesis.

Bessel and Poisson have pointed out that the virtual loss of weight due to oscillation in a resisting medium is greater than that due to the mere immersion. Mr. Moseley makes the same remark with reference to the rolling of ships.

Professor Rankine has investigated the effect of the steadying action of a keel on the rolling in smooth water, on the assumption that the moment of the righting couple is simply proportional to the inclination, and also that the moment of resistance to rolling, caused by the action of the water on the keel and floor is proportional to the angular velocity. He finds[†] that the periodic time is altered from

$$\frac{2\pi k}{\sqrt{g\mu}} \quad \text{to} \quad \frac{2\pi k}{\sqrt{g\mu}\sqrt{1-\frac{g c^2}{4\mu k^2}}}$$

where $c$ is a constant depending on the moment of the resistance, so that

$$c = \frac{\text{moment of resistance of water}}{\text{displacement} \times \text{angular velocity}}$$

the effect of the resistance thus lengthening the periodic time in the same proportion as if the inertia of the rolling mass were increased in the ratio of unity to

$$1 - \frac{g c^2}{4\mu k^2}$$

and periodic rolling in smooth water becoming impossible when $g c^2$ is equal to or greater than $4 \mu k^2$.

### Of Easy and Uneasy Ships.

There is much vagueness in the use of these terms. They are generally applied promiscuously to the practical hindrance caused by motion to the persons engaged in working or manœuvring the ship; to the inconvenience felt by passengers; to the straining of a ship's structure, or the tendency to shift her cargo, or to break away half-fastened weights, like boats or guns.

These all appear to depend in varying proportions on the following data:—The extent or amplitude of angular motion; the rapidity of angular motion; the acceleration of linear motion. But the rapidity of linear motion and the angular acceleration (except so far as this affects bending stress, or as it involves linear acceleration at a distance from the instantaneous axis) do not appear to have much practical influence.

In still water the only motion which is sufficiently great to cause inconvenience is that of rolling. Rolling sometimes produces as secondary phenomena both pitching and dipping; but neither of these are sufficient in extent, in still water to produce inconvenience. The rolling, however, may be considerable, especially in the case of a ship going unsteadily, before the wind. But if the water itself be oscillating, even moderately, or if there be a gusty wind, then a synchronism between any two of the five movements—the wind, the waves, the rolling, the pitching, or the dipping,[‡] or even (to a lesser extent) their concord at regular intervals may cause them to enhance the effects one of another to such an extent as to become inconvenient, and in certain cases dangerous. In the case of a thoroughly uneasy ship in the most unfavourable circumstances, the axis of angular motion may take all conceivable directions; but although any particular point may describe the most irregular curves, both in form and speed, relatively to the vessel's course, yet the chief source of practical danger in open water depends upon the accumulation of motion arising from synchronism.

It appears to have been generally observed that vessels which have a short period of rolling, also roll through large angles. In this way the uneasiness of the rolling undergoes a double increase as the period diminishes. Further and a more exact experiment is required, before we can say how far it is connected by synchronism with wave motion, or whether it is an independent phenomenon. Our present theories do not show it to be a necessary consequence of rolling in smooth water.

### Waves.

We do not consider it necessary to go into a formal discussion of this subject. As regards the behaviour of ships, it is quite sufficient to assume that the profile of a simple wave is trochoidal, and that the particles of water move in circles in a vertical plane, at right angles to the ridges and valleys of the waves. The consequences of this motion are briefly as follows, on the assumption that the depth of water is unlimited. The diameter of the circle, in which a surface particle moves, is the height of the wave from hollow to crest. Particles, which in still water would be at a lower level, describe smaller circles in the same period. A horizontal plane (in the still water) is thus converted into a wave-surface of the same period, but of reduced amplitude of oscillation.[§] The velocity of the particles (and on this depends the impact of a wave) is simply the circumference of one of these circles divided by the periodic time.

If we consider a column of particles which is vertical in still water, that column oscillates in wave water like corn-stalks in a gust of wind, and it also oscillates vertically. But it always slopes towards the crest of the wave, and the obliquity thus induced goes to enhance that due to the wave-slope; so that,

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[*] See "Transactions of the Institution of Naval Architects," vol. v., for 1864, p. 34. See also, Froude, "On Isochronism of Oscillation of Ships," vol. iv., for 1863, p. 218.

[†] The method, with an account of some experimental determinations on several of H.M.'s ships, will be found in the "Transactions of the Institution of Naval Architects,' vol. i., p.; vol. vi., p. 1; vol. vii., p. 205.

[‡] As to this, see Mr. Rankine's note in the "Transactions of the Institution of Naval Architects," vol. v., pp. 31 and 32.

[§] See Dupin, "Applications de Géométrie." He shows that the metacentric heights for rolling and pitching, are, in fact, only the two principal radii of curvature of the surface of centres of buoyancy, and hence the metacentres for intermediate positions may be found by the help of the ellipse of curvature,

[||] See "Philosophical Transactions," for 1850, and Moseley's "Engineering and Architecture," pp. 616, 617.

[¶] "Transactions of the Institution of Naval Architects." vol. iii., p. 31. Mr. Froude has there shown that when a pendulum or ship performs isochronous oscillations in a medium, the resistance of which varies as the square of the velocity, the amplitudes of the successive oscillations, as reduced by resistance, will form successive ordinates of a curve, which approaches, with a great degree of exactness, to an equilateral hyperbola, referred to one of its asymptotes; equal periods of the oscillations being represented by successive increments of the abscissa. The experiments with a pendulum as exhibited in the diagrams (Plate 2 of the volume referred to), accord very closely with the law, which may be thus expressed. If $\theta_0$ be the initial amplitude, and $\theta m$ that at the end of the $m^{th}$ oscillation, then that at the end of any other, say $n^{th}$, will be

$$\theta n = \frac{m\,\theta_0\,\theta m}{(m-n)\,\theta m + n\,\theta_0}$$

[*] "Transactions of the Institution of Naval Architects," vol. v., pp. 20, 31.

[†] "Transactions of the Institution of Naval Architects," vol. v., pp. 30, 31.

[‡] Dipping is the name given to the vertical oscillation of the ship as a whole relatively to the surface of the water.

[§] Drawings of the structure of a trochodial wave will be found in the British Association Reports for 1844, plate 56; "Transactions of the Institution of Naval Architects," vol. i., for 1860, plate 7; vol. iii., for 1862, plate 3; vol. iv., for 1663, plate 10; vol. vi., for 1865, plate 10; "Shipbuilding: Theoretical and Practical" (Rankine), p. 69; Scott Russell: "Naval Architecture," plate 117.

if we regard the profile of a wave, a small portion of water, rectangular when still, undergoes a double deformation, the horizontal surfaces following the wave-slope, and the vertical surfaces being deflected towards the crest; both causes tending to increase the angular deformation, instead of to preserve rectangularity.

The crest of the wave being sharper than the hollow, and the quantity of water invariable, the horizontal plane which lies half way between valley and crest is higher than the mean, or still water, level; and its elevation has been shown to be equal to the height due to the velocity of revolution of the particles.

Considered as trochoids, the wave profiles are traced by a point within a circle rolling under a horizontal line. The line midway between valley and crest is the line of centres. The particles of water above the line of centres are moving forward, as regards the direction of advance of the wave; those below that line backwards. The particles in the front face of the wave are rising, and those in the rear face falling.

The wave whose period is $\frac{1}{n}$th of a second, has a length of

$$\lambda = \frac{g}{2\pi n^2},$$

whence we find the number of waves to a second to be

$$n = \sqrt{\frac{g}{2\pi\lambda}}.$$

The velocity of wave propagation, that is to say, of the apparent advance of the wave in a deep sea, is

$$n\lambda = \sqrt{\frac{g\lambda}{2\pi}} = \frac{g}{2\pi n}.$$

In other words, the speed of the wave crest varies as the periodic time, and the length of the wave varies as their product, or as the square of either.

The vertical disturbance of a particle, whose depth in still water would be $k$, is

$$-\frac{2\pi k}{\lambda}$$

$$h^k = h\,\epsilon,$$

$h$ being the height of the surface wave.

No wave can be sharper than a cycloidal wave. For if the trochoid were looped, the particles in the loop would be unsupported. When the wave form tends to pass the cycloid, it must break.

The extreme observed height of ocean waves appears to be about 40ft., and the greatest observed length 600ft.; these would have a periodic time of 11 seconds (roughly); their crest would advance at a rate of 33 knots an hour, and the velocity of the surface particles would be about 11·4ft. per second. In short waves of the same height the particles of water move faster, in the inverse ratio of the period; but the mass of moving water at the crest of the longer wave is the greater in the ratio of

$$\lambda - \pi h : \lambda^1 - \pi h,$$

where $\lambda$ and $\lambda^1$ are the lengths, and $h$ the height. If, therefore, the above mentioned wave were shortened to 200ft. the surface particles would be moving at a rate of 20ft. a second, while the mass of water in the crest would be about one-sixth. From such data it is easy to infer both the destructive effect of impact from the top of a wave, and the relative quantity of water which a ship would take on board in shipping a sea. The front and rear of a trochoidal wave are exactly similar. Observation, as well as theory, shows that this is true to an extent not commonly believed for ordinary waves. The exceptions are, when the wind is sufficient to push the tops of the waves at extra speed, and when the water shoals rapidly. But even here the relative steepness of the advancing face is exaggerated by most observers. Until a wave is about to break, the actual difference of slope remains very small.

It should be borne in mind that circular orbits and trochoidal wave-surfaces are only approximations, although near enough to the truth for purposes connected with the rolling of ships. In particular, it appears both from theory and observation that there is almost always some progressive motion combined with the orbital motion; and also that waves begin to break long before their crests attain a form so sharp as that of the cusped cycloid; the two slopes at the crest of a breaking wave cutting each other at right angles, or nearly so.*

The ordinary wave of a rough sea is usually an aggregate of waves of different period, and not unfrequently of different direction. For rough purposes, it is sufficient to draw each system of waves separately and add their corresponding ordinates, to get the resulting surface. This can hardly be relied upon in extreme cases; and, in any case, the motion of each particle is not according to any one or more wave systems separately; but it is a motion compounded of what would be due to each separately, if the others were not.

### OSCILLATIONS OF A SHIP AMONG WAVES.

A treatise on "Shipbuilding, Theoretical and Practical,"† edited by Professor Rankine, contains, in a very clear and condensed form, a *résumé* of nearly all that was known on this subject up to 1864 inclusive. The following abstract is chiefly taken from that work:—

It is to be observed that what follows relates to the composition of the ship's oscillation with that of a simple trochoidal wave. The complete problem of a ship's behaviour, depending as it does on wind, waves, rolling, pitching, dipping yawing, variable head resistance, and lateral resistance, and direction of motion relatively both to wind and waves, is far too complicated even for statement, in an exact mathematical form. If a ship floating passively in the water and without any progressive motion were wholly without stability, her centre of gravity, centre of buoyancy, and metacentre coinciding in one point, the motion assumed by that point would be exactly that of the centre of gravity of the mass of water displaced by the ship; that is to say, it would revolve once in each wave-period in a vertical circle of the same diameter, with the orbits of the particles of water situated in the same layer. This motion of the ship has received the name of *passive heaving*, the term being understood to comprehend the swaying from side to side, as well as the rising and sinking, of which the orbital motion is compounded.

Half the difference between the extent of heaving of the ship and the height of the waves is the extent to which, during the passage of the waves, her depth of immersion amidships is liable to be alternately increased above and diminished below her depth of immersion in smooth water. It appears that deep immersion and large horizontal dimensions, but especially deep immersion, tend to diminish the extent of the heaving motion of the ship as compared with that of the waves, and that the effect of those causes in producing this diminution is greatest among comparatively short waves.

The weight of the ship being combined with the centrifugal force due to her heaving motion gives a resultant reaction through her centre of gravity, inclined to the vertical in a direction which, for passive heaving, is perpendicular to the wave-surface traversing the ship's centre of buoyancy (a surface which may be called the effective wave surface), and that direction is the apparent direction of gravity on board the ship, as indicated by plumb-lines, pendulums, suspended barometers, lamps, spirit-levels, and the positions assumed by persons walking or standing on deck. The equal and opposite resulting pressure of the water, acting through the centre of buoyancy, is in like manner compounded of actions due to weight and centrifugal force; and it acts in a line normal to the effective wave-surface, that is to say, parallel to the resultant reaction of the ship. Those two forces balance each other, not when the ship's upright axis is vertical, but when it is normal to the effective wave-surface; and when she deviates from that position they form a righting couple tending to restore her to it. Thus the stability of a ship among waves, instead of tending to keep her steady, as in smooth water, tends to keep her upright to the effective wave-surface; and such is the motion of any vessel or other floating body having great stability and small inertia, such as a light raft. This may be called passive rolling, or rolling with the waves. Passive rolling is modified by the inertia of the ship, which makes her tend to perform oscillations in the same periodic time as in still water by the impulse and resistance of the particles of water against her keel and the sharp parts of her hull which tend, under certain circumstances, to make her roll against the waves, that is, inclining towards the nearest wave-crest, and by other circumstances.

The tendency to keep upright to the effective wave-surface may be distinguished from the tendency to keep truly upright by calling the former stiffness and the latter steadiness. In smooth water stiffness and steadiness are the same thing; amongst waves they are different, and to a certain extent opposed; that is to say, the means used for obtaining one of those qualities are sometimes prejudicial to the other. Stiffness is favourable to the dryness of the ship and to the power of carrying sail; steadiness is favourable to her strength and durability, and the safety of her lading, and in ships of war, to the power of working guns in rough weather. A ship, whose course is either oblique or transverse to the wave crests, is made by the waves to perform a series of longitudinal oscillations, which may be called passive pitching and scending.

In all the oscillatory movements which a ship performs among waves, two series of oscillations are combined—those in which the ship keeps time with the waves, being her passive or forced oscillations, and those which she performs in periods depending on her own mass and figure, as in smooth water, being what may be called her free oscillations. The tendency and ultimate effect of the resistance of the water is to destroy the free oscillations after a certain time, so that the forced oscillations alone are permanent.

Passive heaving, or the motion of a ship when each of her particles performs an orbital motion similar and equal to that of a certain particle of the water in which she floats, takes place when the ship floats amongst waves without having progressive motion. The progression of the ship when under way alters the action of the waves upon her in various ways, which depend mainly upon the apparent period of the waves relatively to the ship—that is, the interval of time between the arrival of two successive crests at the ship, and upon the apparent slope of the effective wave surface in a direction athwart the ship, the latter circumstance being connected mainly with forced rolling oscillations.

When the apparent periodic time of the waves is modified by the progressive motion of the ship, the time during which the forces act, which produce the heaving motion of the ship, is altered in the ratio of the apparent period to the true period; and the extent of the heaving motion is also altered in a proportion which, for moderate deviations of the apparent from the true period, varies nearly as the square of that ratio. This law, however, does not continue to hold for a very great increase of the apparent period, the extent of heaving being less than the ratio first mentioned. Hence the heaving motion of a ship is more extensive than that of the effective wave surface, when the angle made by her course with the direction of the advance of the waves is acute, and less extensive when that angle is obtuse.

Yawing, or swerving of the vessel from side to side by oscillation about an upright axis is, when produced by the waves, the effect of the lateral swaying, which forms the horizontal component of the heaving motion, taking place with different velocities or in opposite directions at the bow and stern of the vessel. The forces producing it are greatest when her course lies diagonally with respect to the direction of advance of the waves.

For reasons already stated a very light and stiff ship tends to float like a raft rolling with the waves, and assuming at every instant the same slope with the effective wave surface. Let a board having very little inertia and no stability be placed so as to float upright in smooth water; then when the water is agitated by waves that board will accompany the motions of the originally upright columns of water—that is to say, it will roll against the waves, inclining at every instant in a direction contrary to the slope of the effective wave surface.

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* See "Philosophical Magazine," November, 1864.

† See pp. 72, 77, of that work.

It has been shown by Mr. Scott Russell,* that the condition of the broad and rounded parts of a ship, and of her hull between wind and water, is analogous to that of a raft; while the condition of the keel, the sharp part of the floor, and the grip and dead wood (or fine parts of the ends) is analogous to that of the board, floating edgwise, so that the ship is under the action of two conflicting sets of forces—gravity, centrifugal force, and pressure (constituting what may be called stiffness), tending to make her roll with the waves, like the raft—and the action of the water on the keel and sharp parts of the hull, which may be called keel resistance, tending to make her roll against the waves, like the board, and hence that she will take some kind of intermediate motion.

It has been pointed out, however, by Mr. Froude and Professor Rankine† that there is an essential distinction between the two sets of forces before mentioned in consequence of which, though conflicting, they are not directly opposed; namely, that the stiffness is an active force, which tends not only to prevent the ship from deviating from a position upright to the effective wave surface, but to restore her to that position after she has left it, with a force increasing with the deviation; while the keel-resistance is merely a passive force, opposing the deviation of the ship from the position of the originally vertical columns of water, with a force depending, not on that deviation, but on the velocity of the relative motion of the ship and the particles of water, and not tending to restore the ship to any definite position. Hence those two kinds of force cannot directly counteract, but only modify one another.

For the mathematical investigation of the action of those forces, reference must be made to the original papers in the transactions of the institution of Naval Architects. The following are the general conclusions:

The permanent rolling of a ship of very great stability, and without any sensible keel-resistance, is governed by the motion of the effective wave-surface, so that she rolls with the waves like a raft. When the period of unresisted rolling of the vessel is to the wave period as $\sqrt{2}:1$, the permanent rolling is wholly governed by the motion of the originally vertical columns of water, so that she rolls against the waves, like a board of no stability floating edgewise. In both of the preceding cases the vessel is upright when the trough or crest of a wave passes her, and her angle of heel is equal to the steepest slope of the effective wave-surface. When the period of unresisted rolling of the vessel is less than the above value, her upright posititions occur before the arrival of the troughs and crests of the waves, and her angle of heel is greater than the steepest slope of the effective wave-surface. The greatest angle of heel in permanent rolling occurs when the period of unresisted rolling of the ship is equal to that of the waves, and it exceeds the slope of the waves in a proportion which is the greater the less the keel resistance, and becomes infinite when the keel resistance vanishes. Thus, isochronism with the waves is the worst quality that a ship can have as regards steadiness and safety. When the period of unresisted rolling of the vessel exceeds that of the waves in a greater ratio than that of $\sqrt{2}:1$, her upright positions occur after the arrival of the troughs and crests of the waves, and her angle of heel is less than the steepest slope of the waves.

The forced or passive oscillations of ships are those which produce the most severe strains, because of their continual recurrence; the free oscillations being gradually extinguished by the resistance of the water. It appears, however, that the periodic time of the free oscillations has an important influence on the extent of the forced oscillations, especially in rolling; the most unfavourable proportions for the periodic time of free rolling to that of passive rolling being those which lie near equality, and between equality and $\sqrt{2}:1$. For the equality of these periods tends to produce an excess of rolling to which it would be difficult to fix a limit; and the ratio of $\sqrt{2}:1$, and those near it, make the ship roll against the waves, thus throwing her into positions in which there is a risk of the wave-crests breaking into her.

A period of free rolling much less than that of passive rolling gives great stiffness, and makes the ship accompany the motions of the effective wave-surface. A period of free rolling exceeding $\sqrt{2}$ times that of passive rolling is favourable to steadiness, provided that this lengthened period be produced by the inertia of the ship, and not by insufficient statical stability. The action of the water on a deep keel, on a sharp floor, or on fine ends below water, tends to moderate the extent of rolling produced by coincidence, whether exact or approximate, of the periods of free and passive rolling; but at the same time it it lessens the effect of a long period of free rolling in producing the same result. A deep draught of water is favourable, on the whole, to steadiness, but not to stiffness. Should the centre of gravity rise and fall relatively to the water in rolling, and the periodic time of the dipping motion so generated happen to be either exactly or nearly one half of that of the passive rolling, the result will be uneasy motion. The steady pressure of the wind on the sails promotes steadiness, at a certain angle of heel, depending on the moment of that pressure; the sudden gusts of the wind produce lurching.

As to pitching, scending, and yawing, it is chiefly important that, for the sake of dryness and safety, those oscillations should be performed in a lively manner among waves; and that object is best promoted by keeping the longitudinal radius of gyration short, as compared with the length of the ship: that is, by taking care not to place heavy weights in her ends.

The true principles of a ship's rolling among waves and their leading consequences were first set forth by Mr. Froude, in a series of papers in the transactions of the Institution of Naval Architects, in 1861, '62, and '63. Mr. Froude appears to have been the first to state the proposition that the tendency of the ship to roll among waves is primarily due to her tendency to keep upright to the effective wave-surface, and that the force which induces this tendency is, very approximately, the same as her stiffness, or resistance, to heeling in still water. The disposition of a ship to follow the average motion of the portion of the wave which she displaces is, however, controlled (as has been pointed out by Mr. Crossland) by the circumstances that the wave water is continually undergoing a deformation of which the ship's hull is not susceptible. Mr. Froude has also shown* that if two plates be hinged together, so that, when in still water, they would float at an inclination of 45° to the vertical, and if the hinge be parallel to the wave-crest, the effect of the wave-motion is simply to open or close the angle between them, and not to alter (sensibly) the horizontal and vertical lines which bisect the angle externally and internally.

As there is nothing to show that the rigidity of the angle between the plates would tend to make any marked alteration in the invariability of direction of the bisectors, the theoretical establishment of this fact is of great importance. Its meaning is that the effect of bilge-keels is to increase the time, and in a greater degree still, to diminish the amplitude of the oscillation, and that the use of bilge-keels is the direct mode of effecting this object.

That the problem of safe rolling is not quite the same with that of easy rolling. A roll towards the wave crest is well known as one of the most dangerous things that can happen to a ship in a high-crested sea-way, for the whole crest of the wave may then break in-board. Even when the ship follows the oscillations of the vertical lines, the wave-particles come flat on the ship's bulwarks and side. If she floats quite vertically she is still in the position of a cliff resisting a wave of the same period whose height is the difference of heights of the surface-wave and of the mean effective wave acting upon her. As regards the impact of a wave, the most violent blow that a wave can give is against a surface parallel to the inflexional tangent and to the wave-crest, and at a level with the line of inflexion. The motion of the particles is then normal to the wave-surface. This remark, of course, does not apply to shore waves.

Throughout the discussion of the ship's oscillation among waves, it has been tacitly assumed that the wave-period itself might be regarded as constant. This is very far from either representing the facts, or the practical problem of the shipbuilder. The wave which a vessel has to encounter may be anything, from the 11 second wave, 600ft. long, to a mere ripple. Practically, a vessel will not roll to waves whose length is much less than her breadth, nor will she pitch much among short waves. But, dismissing these from consideration, it may still be impossible to avoid some contingency in which a ship's period of free rolling may be equal to the wave period. Obviously, the remedy in this case is for her commander not to keep her broadside-on. As a rule, no commander ever would do so in a dangerous sea-way; and even where comfort only is concerned, it is usually open to him either to shorten the effective—that is to say, the apparent wave-period—by putting her head a little to the swell, or to lengthen the apparent wave period by putting her head a little off. He must do one of these things if he meets with actual and exact synchronism in anything like heavy weather.

As a practical matter, Professor Rankine remarks: "It would appear that a very close approximation to the form and proportions which are most favourable to steadiness has, in some cases, been realised by practical trials alone; and that independently of the steadying action of sails; for there are vessels which, when under steam alone, in any moderate swell, keep their decks very nearly parallel to the horizon. It is of great importance that the lines and dimensions, and distribution of the weights of ships, which have been found by experience to possess this excellent quality, should be carefully recorded for the information of naval architects.

"On the other hand, there are vessels (especially screw steamers) whose ordinary extent of rolling each way is from three to four times the slope of the waves."

On the subject of waves, we refer to the following papers and treatises:—Weber—"Wellenlehre." Airy—"On Tides and Waves." Encycl. Metropolitana (reprinted in a separate form). Scott Russell—"Report to British Association," for 1844. Also, "Modern Naval Architecture." Stokes—Cambridge Transactions, 1842 and 1850. Earnshaw—Cambridge Transactions, 1845. Froude—Transactions of the Institution of Naval Architects, 1862, and (incidentally) in his papers "On Rolling." Also, "Remarks on the Differential Wave in a Stratified Fluid," Transactions of the Institution of Naval Architects, vol. iv., for 1863, p. 216. Rankine—Philosophical Transactions for 1863; "Philosophical Magazine," November, 1864; Proceedings of the Royal Society, 1868; Also, Shipbuilding: Theoretical and Practical. Cialdi—"Sul Motto ondoso del Mare." Caligny—Papers in "Lionville's Journal," 1866. D. Stevenson—"On Harbours." With regard to the rolling of ships in wave-water, we believe that almost the only exact investigations are to be found in the Transactions of the Institution of Naval Architects, some of which have been reproduced in Shipbuilding: Theoretical and Practical. They are as follows: Froude—"On the Rolling of Ships," vol. ii., for 1864, p. 180, with Appendices, pp. 44 and 48. Woolley—"On the Rolling of Ships," vol. iii., for 1864, p. 1. Crossland—"On Mr. Froude's Theory of Rolling," vol. iii., p. 7. Rankine—On the same, vol. iii., p. 22. "On the Comparative Straining Action of Different Kinds of Vertical Oscillation upon a Ship," vol. iv., for 1863, p. 203. Scott Russell—Rejoinder, vol. iv., p. 276. Woolley—Memorandum on same subject, vol. iv., p. 284. Rankine—"On the Action of Waves upon a Ship's Keel," vol. v., for 1864, p. 20. "On the Uneasy Rolling of Ships," vol. v. p. 38. Lamport—"On the Problem of a Ship's Form," vol. vi., for 1865, p. 101. Froude—"On the practical Limits of the Rolling of a Ship in a Sea-way," vol. vi., p. 175. Reed—"On the Stability of Monitors under Canvas," vol. ix., for 1868, p. 198. An abstract of the leading principles will be found as already stated in Shipbuilding: Theoretical and Practical, edited by Mr. Rankine.

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* Transactions of the Institution of Naval Architects, for 1863.

† Transactions of the Institution of Naval Architects, for 1863-4.

* Transactions of the Institution of Naval Architects, vol. vi., for 1865, p. 181.

Some valuable practical observations on the rolling of ships in waves will also be found in a pamphlet, "Du Roulis," by Captain Mottez, of the French Imperial Navy.

### MEASUREMENT OF WAVES AT SEA.

This is a thing which has seldom been done with any degree of accuracy. Not only is the vessel moving, but the apparent direction of gravity is not the true one. The result is, that the difference of direction between the tangents to two waves from a point a little behind the spectator is generally taken for the apparent angular height. This may evidently be far in excess of the true apparent height.[*]

Admiral Paris has invented a self-recording instrument for the purpose of measuring both the height and form of waves. A description of this will be found in the Transactions of the Institution of Naval Architects, vol. iii., 1867, p. 279. It is unfortunately a differential instrument, without any means of getting a good datum line. It appears to be much better adapted for getting approximate profiles of complex waves than for obtaining accurate measurements of simple ones. Observations on the lengths of waves present much less difficulty; a float sunk so as not to catch the wind (such as a bottle), and observed from a considerable height, will give the periodic time with a fair degree of accuracy, and the length may be inferred from the period. General observations upon waves[†] are not in point. The object in the present case is to ascertain what the particular waves are in which the ship's rolling is being observed.

### MEASUREMENT OF ROLLING.

It is very well known that a pendulum at sea does not give a vertical line, but a direction due to the joint effect of gravity, of its own free oscillation, and of the forced oscillation due to the motion of its point of suspension. A suspended clinometer is thus perfectly useless for this purpose. Barometers, cuddy lamps, and chandeliers generally oscillate through larger angles than the ship.

Mr. Froude (Transactions of the Institution of Naval Architects for 1862, p. 41) suggests watching the ratlins of the rigging come down to the horizon as a ready and fairly correct way of measuring the roll. The motion of the mast heads relatively to the stars, may be used in the same way.

M. Normand, junior, of Havre, has invented a very ingenious clinometer suspended upon gymbals, like a chronometer, in such a way as to be as little as possible influenced by the ship's motion.[‡] We do not consider that any instrument depending upon gravitation is to be relied upon at sea, and we have been informed that M. Normand himself is not quite satisfied with his instrument.

Apart from observations depending upon the stars, or actual sea horizon, the only only instrument that can be relied upon as giving an invariably plane is of the gyroscope class. A modification of Foucault's gyroscope was tried in the North Sea in 1859, by Professor C. Piazzi Smyth, who gave an account of the instrument and of its performance in the Transactions of the Institution of Naval Architects for 1863, p. 118.

An instrument upon the same rotatory principle, but self-recording, has been invented by Admiral Paris, Hydrographer of the French Imperial Navy. It consists of a spinning top, with its point of support above its centre of gravity. It spins in an agate cup, and the top of the spindle carries a camel's hair pencil, which marks a paper band, driven by clockwork, and passing through bent guides so as to keep close to the pencil. It is described, and some of its curves copied, in the Transactions of the Institution of Naval Architects, vol. iii., for 1867.

What these instruments really give, is the deviation from an undetermined direction. They therefore give the time of rolling or pitching, and of any intermediate oscillation of a periodic character, and the amplitude of deviation from the mean line; but they evidently would not disclose any steady inclination to which the rolling might be superadded. The gyroscope or top will, of course, have its own proper oscillatory revolution, which, however, soon spins out, on the same principle that a pegtop "sleeps."

On the whole there does not seem to be much room for improvement in Admiral Paris's instrument, unless, perhaps, in diminishing the atmospheric resistance. Possibly, also, provision might be made for adjusting the point of support to the centre of gravity.

### RECOMMENDATION OF EXPERIMENTS ON ROLLING.

The mathematical theory of rolling is very far from easy, and leads to equations of which there is no known solution. The time of a common pendulum, for instance, depends upon an elliptic integral, and, beyond the degree of complexity involved in such a junction, mathematics are in the condition of uncleared ground. Accordingly, while it is possible to give a rational account of the immediate gross results of a compound oscillation, these results cannot be expressed or measured with the requisite combination of generality and accuracy. In order to treat them we are obliged to introduce simplifying suppositions, which do not necessarily belong to our problem—as for instance, isochronism—or, the neglect of certain elements of resistance, or the grouping of others.

Now, when this occurs with any branch of practical knowledge, the proper mode of applying mathematical investigation is to start, not from the known principles of general mechanics, but from an advanced base of observations peculiar to the science itself, In hydrodynamics, between minuteness and number, the ultimate molecular unit escapes our notice, and we are only able to observe effects in the gross; being thereby driven to a certain want of detail, both of observation and of reasoning, which allows us to trust our conclusions only when they have been made to rest on a broad experimental foundation. Whether we regard the theory of the propulsion of ships, or that of their rolling, our analysis has assuredly been pushed quite to the extreme verge to which general reasoning can be trusted; and a largely increased extent of exact observation ought to precede further attempts at inductive reasoning on these subjects. We have many exact experiments on propulsion, although, from the complicated character of the phenomena involved, it is difficult to separate the issues; and this will probably not be set right without further special investigation. With regard to the rolling, however, we have much vague observation, and but little exact knowledge, derived from the experiment.

We are not aware of any one published experiment on the rolling of ships in waves, in which the details necessary to make any mathematical use of the results are supplied. The data required are, as a minimum for each case:—1. A draught of the ship, and her calculated elements. 2. The position of her centre of gravity. 3. Her periodic time in still water. 4. The condition of her wet surface. 5. The extent and period of her roll. 6. Was the rolling simple, or mixed with pitching? 7. The height, length, and period of the waves in which she was rolling. 8. Were these waves simple? 9. What alterations have been made in her displacement, her trim, and the position of her weights, as regards both centre of gravity and moment of inertia previously to the trial? 10. Force and direction of wind, and condition of ship as regards resistance to it. 11. Full details as to the manner in which, and the instruments or calculations by which, these data have been ascertained.

There is no no doubt that for a comprehensive view of the subject, it would be necessary that these things should be ascertained with care for a large number of ships, of various classes, and under very varied conditions. But this is too much to expect to get done, although we think it would be a good thing for the Government, and other large ship owners, to keep in view as an ultimate object. Meanwhile, we think it would be a very great experimental aid to science, if these things could be accurately settled for even two or three ships, under different circumstances of weather, and different arrangements of weight, both in amount and distribution.

Similar experiments should also be made with reference to pitching. The trials should be made with sails furled, and as little disturbance from head way as possible. We have every wish to have parallel experiments, tried under any possible conditions of sail and propulsion; and if it may be done, on the same ships, consecutively with the simpler experiments. But it will be seen that the data are already sufficiently complex at the best, and that they must be used clear of headway and leeway before they can be discussed with reference to these. No experiments are of use for the purpose of inductive reasoning, in which any one of the data mentioned above are wanting.

We think the Government might fairly be asked to institute such a set of calculations and experiments. We cannot find that the exact information which we have suggested is in existence anywhere. We are certain that it has not been published in any available form; and we have reason to believe that the knowledge is quite as much as needed and desired by the gentlemen responsible for the construction of the navy, as by merchant builders, or by students of theory.

We therefore recommend that the deputation previously mentioned with reference to the experiments on resistance, be also instructed to urge upon the Admiralty the importance, both practical and theoretical, of instituting such a set of experiments, of providing suitable instruments for recording exact observations, and of publishing the results. We also recommend the appointment by the Council of the Association of a committee of *three* members to confer with the officers of the Admiralty as to the drawing up of detailed instructions for conducting these experiments; and that the Lords of the Admiralty, in the event of their assenting to the proposals, be requested to nominate a committee to confer with the committee named by the Association.

In conclusion, we beg leave to recommend that this report be officially communicated to the Councils of the Institution of Naval Architects, the Institution of Civil Engineers, and the Institution of Engineers in Scotland, and the the co-operation of those bodies sought, both in applying to the Government, and in making known among shipbuilders, and other persons connected with naval architecture, as well what is the state of our existing knowledge, as what are the immediate desiderata for its extension.

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## ON THE MANUFACTURE OF CHLORINE BY MEANS OF PERPETUALLY REGENERATED MANGANITE OF CALCIUM.

By MR. WALTER WELDON.

Since the last meeting of the British Association chlorine has begun to be manufactured extensively by a process which depends on the production and perpetual regeneration of a compound, no mention of which, as far as I can find, as yet exists in chemical literature. As this process, besides thus producing and continually reproducing what I believe to be a new compound, reduces by fully 80 per cent. the principal item in the cost of the manufacture of chlorine, greatly increases the quantity of chlorine which can be practically obtained from a given quantity of hydrochloric acid, and, moreover, enables the manufacture of chlorine to be carried on without the production of any offensive residue, I have ventured to think that a very brief account of it might not be without interest to this Section.

What has hitherto been the ordinary process of manufacturing chlorine consists simply in digesting with hydrochloric acid, ores containing peroxide of manganese. The reaction which takes place, besides liberating chlorine, produces choride of manganese, which remains behind in solution after the chlorine has gone off, and has hitherto been usually thrown away. There has been proposed and tried a great number of processes for transforming this chloride into peroxide for use over again, but the only one of them that has met with the slightest measure of practical success, prior to that which is the subject of this paper, is the one which is known, from the name of its inventor, as Dunlop's process. Dunlop's process decomposes the chloride of manganese by heating its solution, under a pressure of from two to four atmospheres, with milk of carbonate of lime, and then, in the dry way, transforms the resulting carbonate of manganese into a mixture or compound of two equivalents of peroxide with one equivalent of protoxide, by subjecting it for forty-eight hours to the action of air at a temperature of about 600 deg. Fah. The product of Dunlop's process is a sufficiently satisfactory one, containing about 72 per cent. of $MnO^2$; but the process requires a very formidable amount of apparatus, and in this and others ways is so costly that its use has never extended beyond a single firm of manufacturers.

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[*] See Mr. Rankine's remarks in the Transactions of the Institution of Naval Architects, vol. iii., p. 27.

[†] Although very desirable for other reasons.

[‡] See Transactions of the Institution of Naval Architects, for 1860, p. 187.

Three years ago I began to endeavour to work out the idea of decomposing by either lime or magnesia the chloride of manganese in the residual liquors of the chlorine manufacture, and then blowing air through the resulting mixture of hydrated protoxide of manganse with solution of chloride of calcium or of chloride of magnesium, as the case may be. I took for granted that one-half of the protoxide of manganese so treated was the largest proportion of it that could thereby be converted into $MnO^2$—in other words, that one could obtain only sesquioxide by this method; but it was soon found that when using lime to decompose the chloride of manganese considerably more than half the protoxide operated upon was frequently converted into $MnO^2$. It was found eventually that more than half the protoxide was thus peroxidised only when more lime was used than simply the quantity necessary to decompose the chloride of manganese, and when what was treated with air was thus a mixture of manganese and lime; and it was also found that in all such cases there was a definite relation between the quantity of lime associated with the protoxide of manganese and the quantity of the protoxide in excess of half which became peroxidised. This led to the discovery that, whereas when protoxide of manganese by itself is treated with air in the wet way, one-half is the maximum proportion of it which can thereby be converted into $MnO^2$, the association of a certain proportion of lime with the protoxide so treated will enable the whole of it to become converted into $MnO_2$. It is to this fact, together with that of the much greater rapidity with which protoxide of manganese can be peroxidised by treatment with air in the wet way when lime is present than when lime is not present, that the practical success of the new method of manufacturing chlorine is mainly due.

The action of lime in increasing the proportion of protoxide of maganese, which can be peroxidised by treatment with air in the wet way, evidently consists in the lime substituting itself for that part of the protoxide which, when protoxide of mangause, not having any other basic substance associated with it, is treated with air in the wet way, does not undergo peroxidation. It would seem that the production of MnO in the wet way, by direct combination between the hydrated $MnO^2$ and atmospheric oxygen, absolutely requires the presence of a base with which the $MnO^2$ can combine as it forms. When protoxide of manganese, not having any other basic substance associated with it, is treated with air in the wet way, a part of the protoxide itself has to act as the required base; and this is the reason why, in that case, not more than half the protoxide can become peroxidised, the other half being required to combine, as MnO, with the half which becomes converted into $MnO_2$. When, however, the protoxide of manganese, which is treated with air in the wet way, has lime associated with it, the $MnO_2$ which forms (or a part of it, according to the proportion of lime present) combines with CaO instead of MnO, thus leaving free to undergo peroxidation that part of the MnO which, but for the presence of the CaO, this $MnO_2$ must have combined with, and which would thus have got locked up in a state in which it would have been incapable of being peroxidised, at least in the wet way and by air alone. Hence the presence of enough lime to take the place of that half of the protoxide which, if no lime were present, would have to go into combination as base, and also to supply enough base for that half itself to combine with after undergoing peroxidation, will enable the whole of the MnO operated upon to be raised to the state of $MnO_2$. The minimum quantity of lime which is enough for this purpose is an equivalent for each equivalent of MnO operated upon, or the quantity necessary to supply an equivalent of lime to all the $MnO^2$ which can be produced by the peroxidation of all the MnO.

By treating with air, then, a mixture of protoxide of manganese and lime suspended either in water or in solution of chloride of calcium, there is formed a compound containing $MnO^2$ and CaO in the proportion of an equivalent of one to an equivalent of the other. This compound may be regarded as a sesquioxide of manganese, or $MnO^3$, the MnO in which is replaced by CaO. I call it manganite of calcium, and I believe it to be a new compound. Gergeu, in 1862, described a compound which he called manganite of calcium; but his compound contained five equivalents of $MnO^2$ per equivalent to CaO, and the CaO in it was so feebly combined that it readily decomposed chloride of manganese. My compound contains only one equivalent of $MnO^2$ per equivalent of CaO, and has no action upon salts of manganese.

The compound has now been produced and reproduced to the extent of some hundreds of tons. The process of producing it and applying it to the manufacture of chlorine is conducted as follows:—The residual liquor which remains after a charge of manganite has reacted upon hydrochloric acid in any suitable still is run from the still into a well or other receptacle in which it is treated with carbonate of lime, to neutralise any free acid, and to decompose any sesquichloride of aluminium which may be contained in it. The neutralised liquor is then pumped up into an elevated cistern, in which it is left at rest for a few hours in order that it may deposit certain solid matters which it now holds in suspension. The most abundant of these is usually sulphate of calcium, due to the somewhat considerable quantity of sulphuric acid which is nearly always contained in the hydrochloric acid produced in alkali works; but there are also small quantities of sesquioxide of iron, derived from the sesquichloride of iron in the hydrochloric acid, and sometimes partly from the lime used in the process, and larger or smaller quantities of alumina and silica due to the lime. These impurities having deposited, the supernatant liquor, which is a mixed solution of chloride of manganese and chloride of calcium, and is now quite clear and of a beautiful rose colour, is run off into another vessel, where there is added to it the quantity of lime necessary to decompose the chloride of manganese in it and nearly an equivalent more. A blast of air is then injected into the resulting mixture, and what was at first a perfectly white mud, all the manganese in which was in a state of MnO, soon becomes a very black mud, nearly all the manganese in which is in a state of $MnO_2$. This is then allowed to settle for about twelve hours, at the end of which time it has separated into a denser black mud and a supernatant clear solution of chloride of calcium. This solution of chloride of calcium having been drawn off, what remains is ready for use in the still. It is used as mud, without drying, being conveyed to the still by pipes and entering by a hydraulic lute. In the still it meets with the hydrochloric acid, from which it liberates chlorine, at the same time reproducing exactly such a residual solution as was commenced with. With this solution the round of operations is recommenced; and so on, over and over again, continually. The samples I exhibit are portions of a charge of manganese which, at the works of Messrs. J. C. Gamble, and Sons of St. Helens—where this process has been worked out, by the liberal co-operation of Lieutenant-Colonel Gamble, the proprietor of these works, and the invaluable assistance of Mr. Bramwell, the very able manager of them—has actually generated chlorine, from which bleaching powder has been made something like fifty successive times.

Hitherto, the principal item in the cost of chlorine has been that for native peroxide of manganese Last year, in Great Britain, France, Belgium, and Germany together, there were produced about 120,000 tons of bleaching powder, which cost, on an average, for native oxide of manganese, not much, if any, less than £5 per ton. My process substitutes for this cost for native oxide of manganese a cost for the regeneration of manganite of calcium not exceeding fifteen shillings per ton of bleaching powder, being about ten shillings for lime, one shilling for steam, one shilling for wages, and two shillings for interest and wear and tear. Moreover, whereas hitherto, at least in this country and in all but in extremely few exceptional cases, the production of a ton of bleaching powder has required the acid from about 75 cwt. of salt, my compound yields chlorine enough for a ton of bleaching powder from the acid from less than 45 cwt. of salt. This larger yield of chlorine is mainly due to the artificial manganite being so easily soluble that it can very readily be caused to neutralise from 95 to 99 per cent. of the acid employed, which is a very much larger proportion than can be neutralised when working with manganese ores. A third very important advantage of the new process over the old one consists in this, that whereas the immense quantities of acid which escape neutralisation in the old process are usually—and have almost necessarily to be—sent into the rivers as free acid, the only product of the new process which has to be thrown away is a perfectly neutral solution of chloride of calcium.

Seeing that manganite of calcium, or $CaMnO_3$, is only of the same value precisely, in respect of the quantity of chlorine which it can liberate from a given quantity of acid, as sesquioxide, otherwise manganite of manganese, or $MnMnO^3$, it may be well to explain why it is preferable to produce and reproduce the former rather than the latter. The reasons for this are two. There is, firstly, the obvious reason that, when all the manganese is converted into $MnO_2$, twice as much work is done, per given bulk of material operated upon, as when only half the manganese is converted $MnO_2$; and this, of course, would be a very important consideration, even if the transformation of chloride of manganese into manganite of calcium occupied the same time as its transformation into manganite of manganese. Really, however (and this is the second reason), the former operation, in which all the manganese is converted in $MnO_2$, does not occupy more than one-fifth of the time required for the latter operation, in which only half the manganese is converted into $MnO_2$; and hence, while the manufacture of chlorine by means of perpetually regenerated manganite of calcium effects the very considerable economy above stated, it is questionable whether chlorine could be manufactured by means of manganite of manganese, regenerated by the same method, so cheaply as by means of manganese ores.

The length of time which, when protoxide of manganese by itself is treated with the air in the wet way, is required for its complete conversion into sesquioxide is very remarkable, and the fact that hydrated protoxide of maganese is somewhat freely soluable, alike in water and in neutral solution of chloride of calcium, would seem to have something to do with it. It is a curious fact that the peroxidation of protoxide of manganese by treatment with air in the wet way is greatly retarded by the presence in the medium in which the protoxide is supended of any proto-compound of manganese in the state of solution. Thus, in a solution of either chloride or any other protosalt of manganese, peroxidation will go on only extremely slowly; and solution of the protoxide itself, which will be present until the very end of the operation when protoxide alone is treated with air in the wet way, has the same retarding influence. On the other hand, when treating with air a mixture of protoxide of manganese and lime suspended in solution of chloride of calcium, there are formed solutions containing peroxide of manganese, in the presence of which peroxidation goes on with extreme rapidity. All these solutions are more or less deeply coloured, the solution of the protoxide being without colour. I exhibit a sample of one of the coloured solutions, called by the workmen "the port wine solution." The nature of these coloured solutions has not yet been fully investigated, but I believe them to consist of manganite of calcium dissolved in solution of oxychloride of calcium.

I may be permitted to mention, in conclusion, that while there is every prospect, from the rapidity with which the new process of manufacturing chlorine has been and is being adopted both in this country and on the Continent, that within a period to be measured only by months nearly all the chlorine made in the world will be made by it, there is every likelihood that in nearly all cases a portion of the hydrochloric acid saved by it will be applied to the recovery of sulphur from alkali waste. The chief reason why the recovery of sulphur from alkali waste has been so little practised hitherto is that the manufacturers have considered it more profitable to use all their acid for the manufacture of bleaching powder than to use any part of it for the recovery of sulphur; but the process which I have had the honour to describe will enable them to make more bleaching powder than they have hitherto, and yet have enough acid left to permit of their applying to all their alkali waste the only process for the recovery of sulphur therefrom which as yet has been found practically successful, and I am able to state that this application of a portion of the acid saved by my process will be extensively adopted.

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## REMARKS ON METEOROLOGICAL REDUCTIONS, WITH ESPECIAL REFERENCE TO THE ELEMENT OF VAPOUR.

(Communicated to the Kew Committee by **Professor Balfour Stewart**.)

It will be desirable to preface the method of reduction herein proposed by a few remarks on the objects contemplated in such reductions. These objects are twofold. In the first place meteorological reductions may be pursued with the immediate object of acquiring information as to the climate of a place; or, secondly, they may be pursued with the immediate object of extending our knowledge of meteorology, regarded as a physical science.

Thus, for instance, a certain kind of reduction might be imagined to be of immediate practical benefit in determining whether a certain place might suit a certain class of persons or a certain class of plants, but yet it might not materially advance our knowledge of meteorology regarded as a physical science. But, on the other hand, all observations tending to advance our knowledge of meteorology are of undoubted practical benefit. The amount of vapour present in the air is without doubt a very important element of climate, inasmuch as this affects in a marked manner the skin of the human body and the leaves of plants; but I am not aware that it has yet been determined by the joint action of naturalists and meteorologists what is the precise physical function which expresses proportionally the effect of moisture upon animal and vegetable life. Is it simply relative humidity? or does not a given relative humidity at a high temperature have a different effect from that which it has when the temperature is low?

There is, in fact, an absence of information as to the precise physical formula which is wished by physiologists, as expressing the effect of moisture upon organic life. On the other hand, physicists may be presumed to confine themselves to meteorology regarded as a physical science. It is in this latter aspect that I proceed to discuss the question.

Regarding meteorology, therefore, as a physical science, it is one of our objects to ascertain the distribution and laws of motion of the dry and wet components of our atmosphere; and it cannot be denied that we are at the present moment in very great ignorance of these laws.

With respect to the motion of our atmosphere, it cannot be anticipated that we shall ever possess the same sort of knowledge which astronomy gives us regarding the motions of the heavenly bodies; for in the latter case the identity of the object is not lost sight of, while in the former case it is clearly impossible to ascertain the motions of individual particles of air. Our inquiries into the distribution and motion of the elements of our atmosphere must therefore be pursued by that method which enables us to ascertain the distribution and motion of any other substance or product with the individual components of which we find it impracticable to deal.

Suppose, for instance, we wish to ascertain the wealth of our country in grain or in spirits, and the distribution of this commodity over the earth's surface. We should first of all begin by taking the stock of the commodity corresponding to a given date; we should next keep a strict account of all the imports and exports of the material, as well as of its home production and home consumption.

Now, if we have taken stock properly at first, and if our account of the imports, the exports, the production, and the consumption of our material is accurate and properly kept, it will obviously be unnecessary to take stock a second time. But if these accounts are not kept with sufficient accuracy, or if we suspect that our material leaves us by some secret channel which we wish to trace, it will clearly be necessary to take stock frequently; and thus a comparison of our various accounts may enable us to detect the place and circumstances of that secret transit which has hitherto escaped our observation.

Applying these principles to the vapour of our atmosphere, what we wish to know is the amount of the material present at any one station at any moment, and also the laws of its motion. It would appear that the best way of measuring the amount present at any moment is by ascertaining the mass of vapour present in a cubic foot of air, mass and volume being fundamental physical conceptions.

Next, with regard to the motion of the atmosphere, including its vaporous constituent, the method of co-ordinates suggested by Dr. Robinson would appear to be the natural way of arriving at this. Let us set up at a station two imaginary apertures, one facing north and south and the other east and west, and gauge the mass of dry air and the mass of moisture that passes each of these openings in one hour; we shall by this means get the nearest attainable approach to the elements of motion of the atmospheric constituents from hour to hour. We shall not, however, obtain by this means a complete account of this motion, for we have at present no means of measuring its vertical component. This vertical component corresponds in fact to the secret channel in the illustration given above, which we must endeavour to detect by some indirect method. Another thing that ought to be determined is the production or consumption of the vaporous element of our atmosphere as it passes from place to place. This might be done could we keep an accurate account of the evaporation and the precipitation, the two processes by which this element is recruited and consumed. This would, however, be a very difficult observation.

Let us now recapitulate what information regarding moisture we can obtain from such complete meteorological observations as are at present made. We have—(1), The mass of vapour actually present at a station from hour to hour; (2), the mass that passes a station in one hour, going east and west; (3), the mass that passes a station in one hour, going north and south. There is wanting—(4), the vertical component of the motion of vapour; (5), its production or consumption as it passes from place to place.

These deficiencies may, however, be to some extent overcome by the following considerations:—First, the atmosphere moves as a whole when it moves, the dry and moist air moving together; secondly, dry air is neither capable of production nor of consumption, but always remains constant in amount.

To illustrate this part of the subject, let it be supposed we wish to investigate the vertical motion of the atmosphere at a certain station. Make this station the imaginary centre of a circle, the circumference of which may be supposed to be studded with other stations at sufficiently frequent intervals, so that we can tell, hour by hour, how much dry air passes in towards the centre of the circle through its circumference, and also how much passes out.

Let us suppose that more is passing in than is passing out, or that the imports into the area of the circle are greater than the exports out of it. Now the dry air that passes in is incapable of production or of consumption, and hence the stock of the material at the central station, and in the area generally, ought to be on the increase, since we have imagined the imports to be greater than the exports. If, however, we ascertain from actual observation that the stock of dry air is diminishing instead of increasing, we may be sure that some is carried off by an upward current, which of course carries the moisture with the dry air.

So much for the vertical component; and, in the next place, with regard to the production or consumption of aqueous vapour as it passes from place to place. Our consideration has hitherto been confined to quantity; let us now define what is meant by the hygrometric quality of the air. It may be represented by the following quotient:—

$$\frac{\text{mass of vapour in a cubic foot.}}{\text{mass of dry air in a cubic foot.}}$$

Now this quotient can only alter by evaporation, by precipitation, or by mixture. This hygrometric quality of the air may perhaps be considered as a quality sufficiently constant to aid us in tracing the actual motion of air, just as we may make use of the element of saltness to trace the actual path of an oceanic current. But besides this aid, we may make use of it to enable us to tell the precipitation or evaporation. For instance, a very damp air, in passing over a very dry country, may be supposed to emerge less damp, having its hygrometric quality changed; or a very dry air, in passing over a very damp country, may be supposed to emerge less dry, having its quality changed in the opposite direction. Thus, by actual observation of the quality of the air at the time of its reaching some particular tract of land or ocean, and at the time of its leaving it, we may possibly get much better observations of what goes on in the country, as far as this particular research is concerned, than if it were studded with gauges.

I should therefore suggest that meteorological observations should, by a system of reduction, be made to show—(1), The mass of dry air and of moisture in one cubic foot actually present at each station from hour to hour; (2), the mass of dry air and of moisture that passes each station, hour by hour, in two lines of direction at right angles to each other, namely, north and south, and east and west.

When these hourly elements are obtained they might for seasonable changes be reduced after the method of five-day means, or for the investigation of abrupt changes of weather, such as storms, they might be utilised in some other way.

Retaining the belief that meteorology ought to be treated as much as possible with the view, in the first place, of determining the actual motions of our atmosphere, and, in the next place, of assigning the cause of these, it is no doubt the greater movements of the atmosphere that will be indicated by five-day means. It ought, however, to be remarked that the observations at any station are subject to the influence of locality, none probably more so than those of wind. It would appear that this influence ought to be eliminated before we can make any trustworthy quantitative deductions regarding the greater movements of our atmosphere. I should, however, imagine that the quality of the air, as herein indicated, may be made of immediate use in the study of storms.

It has been suggested by Mr. Meldrum, who expresses his concurrence with the above remarks, that in addition to the five-day means indicated above, there might be given a brief epitome of the weather. Thus, for instance, "The wind blew from the N.E. at Kew from January 1st, 1 a.m., to January 4th, 3 p.m., in all eighty-six hours, at the average velocity of sixteen miles an hour, with an average pressure of 30in., a temperature of 40deg. Fah., and an average hygrometric quality represented by ·075." The same remarks had previously occurred to myself, and Mr. Airey also has recently suggested the study of the meteorological phenomena of those periods during which the wind blows in the same direction.

## ON SOME DIFFICULTIES IN THE RECEIVED VIEWS OF FLUID FRICTION.

By Mr. W. Froude.

The very great variations in the resistance offered to the flow of water through the main of the Torquay water supply, arising from apparently small variations in the roughness of the interior surface, have led me to think that our views of the character of that action which is commonly termed "fluid friction," or "skin resistance," requires further investigation, and perhaps material revision.

The accredited laws that are held to govern the resistance arising from this action are based on the following considerations. (1) That the resistance offered by each square foot of rubbing surface in a given plane moving edgewise, is the same throughout the plane; (2) That it is as the square of the velocity of the surface through the surrounding fluid, or of the surrounding fluid past the surface. And this relation is usually expressed by a simple coefficient, the value of which is known to vary somewhat with the quality of the surface, being increased by its roughness, and is held to be somewhat less for high velocities than for low.

If we express the friction by $f = k v^2 a$, $v$ being the velocity in feet per second, and $a$ the friction bearing area in square feet, the value of $k$ as deduced from Beaufoy's experiments with a smooth painted plank moving through open water is 0·0034, while Professor Rankine takes it at about the same value, or 0·0036 for clean painted iron. And as deduced from Professor Rankine's rules for the flow of water through pipes of cast iron, its value appears to vary between 0·0092 for velocities of about 1 ft. per second, and 0·0056 for velocities of about 4 ft. per second.

The excess which is observed in comparing the coefficient of resistance suitable for the internal surface of a pipe, with that suitable for smooth surfaces in open water, represents the circumstances that the central or maximum velocity of the contents of a pipe considerably exceeds their mean velocity; and that a cast iron surface—that commonly referred to in pipes—is probably inferior in smoothness to a painted surface, while the excess in the coefficient appropriated to the higher velocity, represents the probability that the imperfect fluidity of water is more felt when the velocity is small.

The *rationale*, if I may use the term, by which the flow of water through a pipe is deduced from this coefficient of friction, and the internal area of the pipe, involves the assumption that one and the same multiple of the mean velocity, is equally applicable to all pipes of whatever diameter, as the effective velocity in virtue of which the coefficient is to be applied.

This assumption will now determine the resistance which each length-unit of pipe of given diameter, will offer in virtue of the velocity of flow; and if the mean declivity, or hydraulic gradient be also given, the velocity must be such that this resistance shall exactly balance the force which the weight of the corresponding length-unit of internal water column, exerts along the pipe in virtue of the gradient.

The usual formulæ are thus deduced, which give the mean velocity as proportioned to the square root of the diameter and the square root of the gradient, and the delivery per minute as proportion to the power $\frac{5}{2}$ of the diameter and the square root the the fall.

This mode of viewing the question does not essentially differ from that of supposing the enclosed column of water, to glide bodily along the interior of the pipe, and the resistance to be delivered at a definite rubbing surface as with solid friction, depending, however, not on pressure of contact, but on velocity of gliding. And the supposition seems to lead to some irreconcileable consequences.

The character of the motion involved in it, may be geometrically represented as follows:—

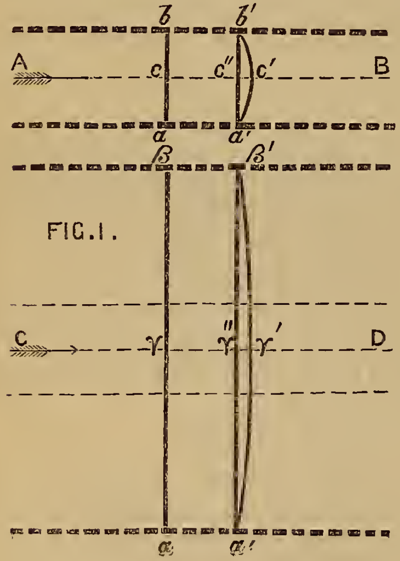

FIG. 1.

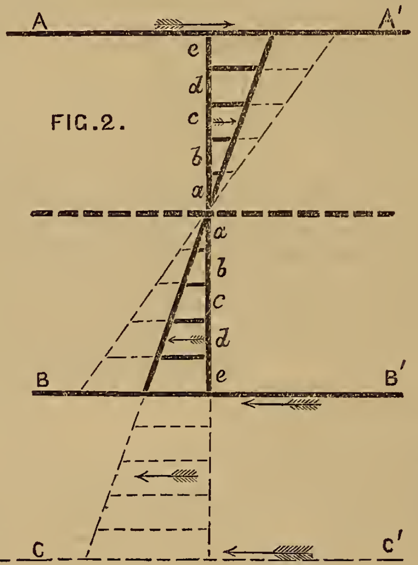

FIG. 2.

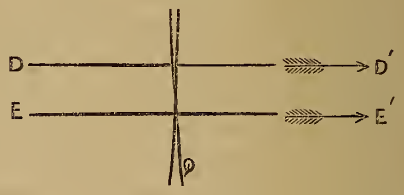

FIG. 3.

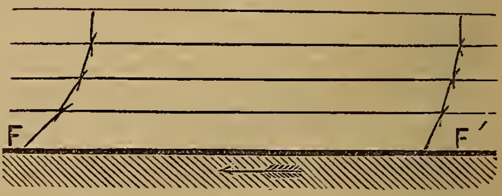

FIG. 4.

Let A B, Fig. 1, be a portion of pipe having a diameter = unity, and let the water within it be flowing in obedience to some given hydraulic gradient, and therefore with some definite mean and effective velocities, say V and V′.

Let *a c b* be the line occupied at any moment by a series of diametrically placed particles; then the supposition which we are examining will be represented by assigning to these particles, after the lapse of a definite unit of time, some new position, *a′ c′ b′*, in which *a a′* and *b b′* will represent the effective velocity, and the ordinates of the curvilinear are *a′ c′ b′ c″* will represent the excess of the mean over the effective velocity, or (V—V′)

Let us now compare with this, the state of things which on the same supposition will similarly ensue in a pipe of larger, say quadrupled diameter, under the same hydraulic gradient, and let this pipe be represented by C D.

In this case, since by the formula the velocity is as the square root of the diameter, the effective and the mean velocities will alike be doubled; and a series of displacements, throughout equal to those which take place during the unit of time in the small pipe, will take place during half that unit in the larger pipe.

Forming a diagram on this basis, we shall have $\alpha\,\alpha' = a\,a'$, and so on throughout.

Now it appears to me difficult to believe that the particles along the line $\alpha'\,\beta'\,\gamma'$, which has a quadrupled length, and therefore presumably a greater mobility, in the larger pipe, will not be bent forward in the middle through a wider space than the particles along $a'\,c'\,b'$ have been bent forward in the smaller pipe, which are all so much nearer to the restraining surface. Or to place the difficulty in a more definite shape, if we mentally picture to ourselves within the larger tube, the conditions of a central column of water having the same diameter as the smaller tube, as indicated by the dotted lines, I do no see why we ought not to expect that central column to glide forward as rapidly past the moving particles which immediately surround it, as the similarly placed particles in the smaller tube glide forward within the fixed surface of the tube; unless it be more difficult for particles of fluid to slide past one another, than for them to slide past a fixed surface.

Viewing the matter in this light, I am led to the conclusion that there is no real justification for the idea of discontinuity in the velocity where the water meets the surface, and that the "state of motion" must really consist of a graduated series of velocities increasing from the circumference to the centre, annulus sliding within annulus, and the resisting force being a function, not of some arbitrarily assumed effective absolute velocity, but of the relative velocities of contiguous particles.

This crude suggestion may be framed into a more intelligible hypothesis, if embodied in a diagram which presents it under a somewhat different aspect.

Let A A′, B B′, fig. 2, be two planes of infinite extension, guided so as to move edgewise parallel to one another, and moving with equal uniform velocities in opposite directions, the intervening space being filled with water. Then when the state of intervening motions and forces has become established, there are several consequences of the supposition which may at once be regarded as certain.

In the first place, each plane will experience a definite resistance per square foot the same throughout along its line of action, and the same for both; and these equal and opposing forces must be somehow transmitted from the one plane to the other, square foot by square foot, through the intervening water, maintaining in it a definite constant state of motion.

In the next place, the particles in absolute contact with each plane will be moving with the velocity of the plane.

Further, the line of particles midway between the planes must be stationary, since it is symmetrically situated with reference to the two equal and opposite motions and forces.

And lastly, any intervening particle on either side of the central line, must be moving with some graduated velocity, accordant with that of the plane to which it is nearest.

Now if the planes be so free from roughness as to be incapable of imparting lateral impulse to the water, it seems clear that the growth of velocity on either side of the central line must be uniform as we recede from the centre. For if we imagine the intervening fluid as consisting of successive parallel layers of equal thickness, each layer must be so moving past the contiguous layer as to transmit to it, square foot by square foot, that identical force which is experienced as resistance by the boundary planes. And it would seem therefore that layer *a* must be passing player *b* as fast as layer *b* is passing layer *a*, and so on throughout. The ordinates of the triangular spaces shown on either side of the centre, will thus represent the respective velocities of the corresponding particles.

If this view be sound, it follows that were we to establish a third plane C C′, making the distance B C (say) = ½ A B, and were we to assign to this plane a comformable velocity double that of the plane B B′, and let the intervening space be filled with fluid, carrying on the established growth of velocity as before, in a continued series to the outer plane, we should, under these circumstances, transmit to that outer plane exactly the same force per square foot as that experienced on the original planes; and the plane B B′ would meanwhile assume merely the condition of one of the intervening layers of fluid, becoming a mere neutral instrument in the transmission of force and motion. We should thus have, on the plane C C′, moving with an absolutely double velocity, only the same velocity relatively to the contiguous water, and only the same force per square foot, as on the plane A A′, moving with the single velocity.

Thus it would seem that the so-called force of friction may be more properly regarded rather as "resistance to deformation" than as "friction" in the usual sense of the term, and that its measure depends not on the absolute velocity of the moving solid surface which initiates the deformation, but on the rate at which the deformation is transmitted from layer to layer. Thus though the doubled velocity of the plane C C′ subjects it to no enhanced resistance, since the rate of transmitted deformation is in that case unchanged, yet if we had doubled the velocities of the two original planes A A′, B B′, we should have enhanced the rate of transmitted deformation, and in some degree, as yet unknown, we should have also enhanced the resistance.

We have thus to regard the resistance as governed by what we may term the "angle of deformation," say $\varphi$, which might be defined as the change of angular position which, in a given infinitesimal unit of time, the relative motions of two closely contiguous particles, impose on a line which at the commencement of the interval was at right angles to the line of motion; thus expressing the space by which during the assumed interval of time $dt$ any particle in the line E E′, Fig. 3, is carried past its opposite particle in D D′, in terms of the interval between the lines. The resistance will probably be some function of $\phi$.

In the case of the infinitely extended parallel planes just now considered, $\varphi$ was constant through the whole intervening space. But in the case where a plane is being intruded into a volume of stationary particles, $\varphi$ will be found to vary in terms of $h$, the lateral distance between the particles concerned and the plane, as well as in terms of $s$, the distance along the plane. And at any distance along the plane $\left(\frac{d\phi}{dh}\right)$ will contain a measure of the varying force which penetrates the surrounding fluid, so far as this has become affected by the motion, and will thus also contain a measure of the accelerating force which actuates the intervening layer; because it expresses how much greater a force is dragging the layer forward on one face, than is dragging it backward on the other. This state of things is represented in Fig. 4.

From this mode of viewing the subject, it would follow that when a plane of considerable length is moving edgewise through undisturbed water, a square foot of surface at its head-end, must experience a greater resistance than one near its stern-end, because the force exerted by the head-end has already imposed force and motion on the particles which flow past it, and the state of motion must have spread into the surrounding fluid, so that at the stern-end the value of $\varphi$ and of $\left(\frac{d\varphi}{dh}\right)$ will both be less than at the head-end.

Were the law of force in terms of $\varphi$ known, it would be possible to construct a differential equation which would show the rate of accumulation of the current along the side of the plane, and its penetration into the surrounding fluid.

That some such correction of the usual views on the subject is required, appears to me to be inevitably involved in the fact that the growing current I refer to, visibly as well as necessarily exists.

It seems a paradox to say that the stern-end can experience as much force per square foot as the head-end, where there exists a favourable current of considerable velocity and of considerable thickness alongside the latter. It is equivalent to saying that were we to plunge a plane edgewise into this favouring current it would experience as much resistance as if we plunged it into the as yet undisturbed water outside the current.

I may add that of all the conditions affecting the resistance of a ship, this alone seems to me to perplex the comparison between the resistance of a ship and of a model similar to the ship; but it must equally perplex the comparison between the resistance of similar ships of different sizes; and the law which governs the condition will be readily determinable by experiment.

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## RAILWAY PASSENGER AND GUARDS' COMMUNICATION.

### By Mr. S. A. Varley.

Mr. S. A. Varley remarked that the subject was one which had occupied considerable attention, and he thought the points he would now lay before them would be of some interest. He proceeded to describe his system of communication which was applied in 1866, and is at the present time in use on the royal train in which Her Majesty travels to and from the north. There appeared to be a belief on the part of some (but by no means all) of the railway authorities, that owing to the subtle nature of electricity it would not answer the purpose of train intercommunication. But this opinion he thought was only entertained by those who did not know the progress that had been made of late years in electricity. The only difficulty in the matter was the mechanical construction of an apparatus to answer the purpose. It was suggested by the railway authorities that it should be simple and not liable to disarrangement, passengers should be able easily to signal to the guards in emergency, and the apparatus should be detective so as to prevent trifling. Besides this—for the sake of economy—it should be easy of removal, so that one apparatus should not necessarily be confined to one train of carriages. Three electrical systems had been practically applied. The first on the list was that of Mr. Preece's, in use on the London and South-Western Railway; the second Mr. Walters', in use on the South-Eastern Railway; and the third that invented by Mr. Martyn, with whom he (Mr. Varley) was connected, and which was used on the North-Western Railway. All three systems fulfil more or less the conditions laid down as required. They, however, differed in the mechanical construction of the couplings, the alarums, the carriage signalling apparatus, and the galvanic batteries. He would not discuss their respective merits but merely describe the system with which he was connected. It appeared that an insulated wire ran along under the carriages which communicated with a battery in the guard's van, and another on the engine. Two insulated wires from each compartment were connected with the one under the carriages, and these were attached to a handle in each compartment. This handle, on being pulled out (and which would not again go back without a key), set the electric apparatus in motion, striking a bell in the guard's van and on the engine, which would not stop ringing until the handle pulled by the passenger raising the alarm was put back in its place by the guard in possession of the key for that purpose. The insulated wire running under the carriages was in reality seven wires in one coil, which were covered with a flexible material and found to be very durable, and not likely to break on going round curves, which was one great objection to the ordinary "rope system." The maintenance of his system was very simple and the cost nominal. No electric knowledge was necessary in testing the different portions of the system as all the operations are purely mechanical. The batteries continue to work two or three months without attention, and warning of any failing is given by the fainter working of the bell. This system, at the request of the Board of Trade, was fitted up in a train running daily from London to Wolverhampton—250 miles. The train was started from all stations at which it stopped by means of the apparatus, and its working reported by the guards in their daily reports. The apparatus was tested daily twenty-two times, and its performance, as shown by those reports, has been marked by the most unvarying regularity.

## A NEW AND ECONOMICAL METHOD FOR EFFECTING THE EXTRICATION AND CONDENSATION OF AMMONIA FROM GAS LIQUOR FOR PURPOSES OF CHEAP CARRIAGE, AND FOR FACILITATING THE MANUFACTURE OF AMMONIACAL SALTS.

By Frederick Braby, F.G.S.

It is but a very few years since that the various bye-products obtained from the manufacture of coal gas were not merely a drug in the market, but proved an absolute nuisance to the manufacturer and to the general public.

Coal tar was even burnt under the retorts, or was introduced therein for for the production of gas; and gas liquor was commonly given away to anyone whose ingenuity might enable him to turn it to a useful purpose.

But the progress of science in this, as in other cases, soon discovered applications where none were supposed to exist.

From coal tar are not only now obtained naphtha, benzol, carbolic acid, and other valuable derivatives, but also the brilliant and diversified colours of what are called aniline dyes are obtained from the same source. The ammoniacal liquor, too, to which, on the present occasion, I desire to be favoured with your attention, is now not only not given away in the Metropolitan and other districts, but in certain localities the greatest competition exists for its acquisition. It at present constitutes, in this country, the principal source of ammonia, and, consequently, of the ammoniacal salts, which are so usefully and so successfully applied in the arts, and more especially to agriculture. In London and its neighbourhood, the purchase of the residuary products of the various gas companies is eagerly sought after, and it is now considered a privilege to be allowed permission to tender for them for the term of one, two, or more years' supply. Practically, the tar and gas liquor trade is in the hands of a few parties jealously desiring to exclude outsiders, who thus find it extremely difficult and often absolutely impossible to obtain even a few thousand gallons.

The object of the present communication is to show how the demand for gas liquor which so far exceeds the means of actual supply can be met. It is to show, moreover, that by condensation and reduction of bulk for transport, small and remote gas works may be enabled to utilise and export their residual products at a profit; and above all, how, by the introduction of certain improvements, the quantity of ammonia as produced and utilised from the manufacture of gas, may be practically increased from ten to fiftyfold.

The strength of gas liquor is commonly specified in the various tenders as technically 6 oz. The prefix, denoting the number of ounces, refers to each gallon of the liquor, and does signify the number of ounces of ammonia that are present, but the number of ounces of sulphuric acid which would be required to neutralise the ammonia. Consequently a butt of 108 gallons of 6-oz. liquor implies, by calculation, that 108 times 6 ozs. or 40 lbs. of sulphuric acid are required to saturate the whole quantity. Now it is found in practice that, if we divide the quantity of sulphuric acid by three, we shall get at the quantity of ammonia actually present. This result closely agrees with theory, the equivalent of dry ammonia being 17, and that of monohydrated sulphuric acid (oil of vitriol) being 49; the proportion is very nearly 1 in three. It follows, therefore, that, as 40 lbs. of sulphuric acid are required to saturate a butt of 6-oz. liquor, so one-third of this or little more than 13 lbs. of real ammonia are contained in this immense quantity of liquid and merchantable product, weighing as it does in the aggregate no less than 1,107 lbs., or half a ton. On referring to the ordinary commercial standard, viz., of 6 ozs. to the gallon, 6 ozs. of sulphuric acid divided by 3 gives 2 ozs. of ammonia as the entire quantity present. Now a gallon of the gas liquor weighs 10 lbs., and, if the lbs. be multiplied by 16 to reduce them to ounces, we have a total of 160 ozs., containing only 2 ozs. of real ammonia, or 1 oz. to 80 ozs. of water.

The result of this is, practically, to prohibit the transport of gas liquor over any but moderate distances, because, in its present form, for every ton of real ammonia carried by barge, tank-cart, or otherwise, no less than 80 tons of water must be carried for no other purpose but as a solvent. It must not be inferred, however, that the whole of these 80 tons of water is waste carriage. Ammonia in a free state cannot be conveniently carried, except when dissolved in a certain quantity of water. It would not be judicious to concentrate the ammonia to a higher degree than 0·900, since, if, in course of carriage, it were subjected to any degree of heat, the water at an elevated temperature would disengage some of the $NH_3$ held in solution, and such a disengagement of ammonia might be attended with dangerous results. A very useful and safe solution for all purposes of transit would be about one part by weight of ammonia to four parts of water; this would reduce the present cost of carriage for this important article no less than twenty times, or, in other words, the transit of a certain quantity of ammonia over a certain distance costing now £20 would, if conveyed in the above concentrated form, be reduced to 20s. This scale of reduction would at once enable it to be carried by rail in petroleum or other barrels, or in tank-trucks, or otherwise, and would bring the numerous gas works which are scattered over the United Kingdom within economical transport of the centres of manufacturing industry, so that this important bye-product of gas-making might be utilised for the general good, and be not so extensively wasted as has been, and is now, frequently the case.

In order to effect this desirable object, I recently, in conjunction with Mr. Baggs, secured a patent for effecting the necessary concentration of ammonia by certain novel means, which promise in practice to prove far more rapid and economical that any hitherto employed. The process may be shortly described as follows:—To the common ammoniacal gas liquor a certain quantity of slacked lime is added. The liquor thus treated is placed in a capacious boiler or still containing from four to five thousand gallons. The whole is then heated and maintained at a temperature of from 100° to 200° F., the liquor being slowly but constantly stirred by means of an internal agitator, the spindle of which passes through a stuffing box in the end of the boiler. A powerful blast of air from a double-action force-pump actuated by a small steam engine or otherwise, is blown continuously through the liquor. The air enters by two long perforated pipes placed near the bottom of the boiler, and in its upward passage it is compelled to pass through a horizontal diaphragm drilled with numerous small holes. The result of this arrangement being that the air, in its ascent, is subdivided into innumerable small sheaves and bubbles, to each and all of which, in accordance with well-known and recognised laws, the ammonia attaches itself and is carried away with only a very small proportion of aqueous vapour. An exit pipe is fixed to the top of the boiler, so as to carry away the mixture of air and ammonia, and the extremity of this pipe dips into a supply of water contained in a cold and suitable receiver, where the ammonia is immediately absorbed, and the air after thus effecting its removal in a separate state escapes through the water and is permitted to pass off into the atmosphere. The condensers are generally arranged like a series of what are known as Woulfe's bottles, but for the purpose of obtaining great strength and purity, this arrangement may be superseded in the manner following.

(*To be continued*).

## ROYAL SOCIETY OF GREAT BRITAIN.

## BAKERIAN LECTURE.—ON THE CONTINUITY OF THE GASEOUS AND LIQUID STATES OF MATTER.

By Thomas Andrews, M.D., F.R.S., &c.

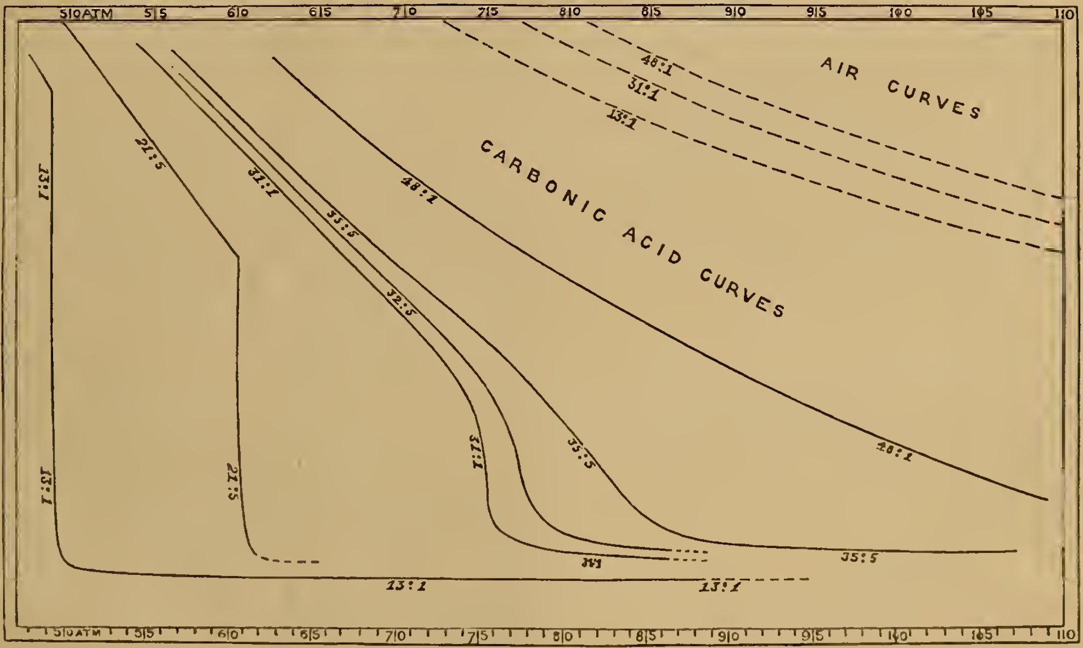
(Abstract.)

In 1863 the author announced, in a communication which Dr. Miller had the kindness to publish in the third edition of his "Chemical Physics," that on partially liquefying carbonic acid by pressure, and gradually raising at the same time the temperature to about 88° Fahr., the surface of demarcation between the liquid and gas became fainter, lost its curvature, and at last disappeared, the tube being then filled with a fluid which, from its optical and other properties, appeared to be perfectly homogeneous. The present paper contains the results of an investigation of this subject, which has occupied the author for several years. The temperature at which carbonic acid ceases to liquefy by pressure he designates the critical point, and he finds it to be 30°·92 C. Although liquefaction does not occur at temperatures a little above this point, a very great change of density is produced by slight alterations of pressure and the flickering movements, also described in 1863, come conspicuously into view. In this communication, the combined effects of heat and pressure upon carbonic acid at temperatures varying from 13° C. to 48° C., and at pressures ranging from 48 to 109 atmospheres, are fully examined.

At 13°·1 C., and under a pressure, as indicated approximately by the air manometer, of 48·89 atmospheres, carbonic acid, now just on the point of liquefying, is reduced to $\frac{1}{80\cdot5}$ of the volume it occupied under one atmosphere. A slight increase of pressure, amounting to $\frac{1}{20}$ of an atmosphere, which has to be applied to condense the first half of the liquid, is shown to arise from the presence of a trace of air ($\frac{1}{1000}$ part) in the carbonic acid. After liquefaction, the volume of the carbonic acid, already reduced to about $\frac{1}{470}$ of its original volume, continues to diminish as the pressure augments, and at a much greater rate than in the case of ordinary liquids. Similar results were obtained at the temperature of 21°·5. A third series of experiments was made at 31°·1, or 0°·2 above the critical point. In this case the volume of the carbonic acid diminished steadily with the pressure, till about 74 atmospheres were attained. After this, a rapid but not (as in the case of liquefaction) abrupt fall occurred, and the volume was diminished to one-half by an additional pressure of less than two atmospheres. Under a pressure of 75·4 atmospheres, the carbonic acid was reduced to $\frac{1}{311}$ of its original volume under one atmosphere. Beyond this point it yielded very slowly to pressure. During the stage of rapid contraction there was no evidence at any time of liquefaction having occurred, or of two conditions of matter being present in the tube. Two other series of experiments were made, one at 32°·5, the other at 35°·5, with the same general results, except that the rapid fall became less marked as the temperature was higher. The experiments at 35°·5 were carried as far as 107 atmospheres, at which pressure the volume of carbonic acid was almost the same as that which it should have occupied if it had been derived directly from liquid carbonic acid, according to the law of the expansion of that body for heat.

The last series of experiments was made at 48°·1, and extended from 62·6 to 109·4 atmospheres of pressure. The results are very interesting, inasmuch as the rapid fall exhibited at lower temperatures has almost, if not altogether, disappeared, and the curve representing the changes of volume approximates closely to that of a gas following the law of Mariotte. The diminution of volume is at the same time much greater than if that law held good.

The results just described are presented in a graphical form in the figure given below. Equal volumes of air and carbonic acid, measured at 0° C. and 760 millemetres, when compressed at the temperatures marked on each curve, undergo the changes of volume indicated by the form of the curve. The figures at the top and bottom indicate the approximate pressures in atmospheres; the volumes of the gas and air are measured upwards from the dotted horizontal line.



The author has exposed carbonic acid, without making precise measurements, to higher pressures than any of those mentioned, and has made it pass, without breach of continuity, from what is universally regarded as the gaseous to what is, in like manner, universally regarded as the liquid state. As a direct result of his experiments, he concludes that the gaseous and liquid states are only widely separated forms of the same condition of matter, and may be made to pass into one another by a series of gradations so gentle that the passage shall nowhere present any interruption or breach of continuity. From carbonic acid as a perfect gas, to carbonic acid as a perfect liquid, the transition may be accomplished by a continuous process, and the gas and liquid are only distant stages of a long series of continuous physical changes. Under certain conditions of temperature and pressure, carbonic acid finds itself, it is true, in a state of instability, and suddenly passes, without change of pressure or temperature, but with the evolution of heat, to the condition which, by the continuous process, can only be reached by a long and circuitous route.

The author discusses the question as to what is the condition or state of carbonic acid when it passes at temperatures above 31° from the ordinary gaseous state down to the volume of the liquid, without giving any evidence during the process of the occurrence of liquefaction, and arrives at the conclusion that the answer to this question is to be found in the intimate relations which subsist between the gaseous and liquid states of matter. In the abrupt change which occurs when the gases are compressed to a certain volume at temperatures below the critical point, molecular forces are brought into play, which produce a sudden change of volume, and during this process it is easy to distinguish, by optical characters, the carbonic acid which has collapsed from that which has not changed its volume. But when the same change is effected by the continuous process, the carbonic acid passes through conditions which lie between the ordinary gaseous and ordinary liquid states, and which we have no valid grounds for referring to the one state rather than to the other.

Nitrous oxide, hydrochloric acid, ammonia, sulphuric ether, sulphuret of carbon, all exhibited critical points when exposed under pressure to the required temperatures.

The author proposes for the present arbitrary distinction between vapours and gases, to confine the term vapour to gaseous bodies at temperatures below their critical points, and which therefore can be liquefied by pressure, so that gas and liquid may exist in the same vessel in presence of one another.

The possible continuity of the liquid and solid states is referred to as a problem of far greater difficulty than that which forms the subject of this communication, and as one which cannot be received without careful investigation.

## REVIEWS AND NOTICES OF NEW BOOKS.

We have received the following works recently issued by M. Eugene LaCroix, Paris, the celebrated French publisher of Scientific, Industrial, and Agricultural Works, who is also the publisher to the "Société des Ingenieurs Civils."

1. *Industries Anciennes et Modernes de l'Empire chinois, d'après des notices traduites du chinois, par M. Stanislaus Julien, Membre de l'Institut, et accompagnées de notices industrielles et scientifiques, par M. Paul Champion. Preparateur de Chimie au Conservatoire des Arts et Metiers à l'Ecole centrale des arts et manufactures, Professeur de Chimie à l'Association Polytechnique, Ancienne Délégué de la Société d'acclimatation en Chine et en Japan.*

The work of M. Stanislaus Julien under notice cannot fail to be interesting to everyone, but especially so to the student of Eastern life and customs. In its pages are minutely narrated processes of the manufacture of the numerous productions of the Celestial Empire, with which we are so familiar, and of the fabrication of which we know so little. In the preface the author gives a slight sketch of the first intercommunication of the Western nations with the great Chinese Empire. He says:—

"It was in the year 1514 that the Portuguese obtained from the Emperor Ou-tsoung permission to form a trading station at Macao. At this epoch it may safely be asserted that European industry and manufactures were at their lowest ebb, and it can be readily understood that the attention of Western nations was greatly attracted to the articles of manufacture then imported, the beautiful workmanship and elaborate finish of which displayed a degree of civilisation in the East till then scarcely dreamt of."

The author then describes the numerous manufactures in which the Chinese excel, detailing the various processes with a minuteness which can only have been attained by means of long continued personal observation. They are arrayed under the following divisions:—Combustibles, salt, sulphur, saltpetre, talc, gunpowder, glass, soda, mineral and vegetable colours, gold, silver, tin, zinc, copper, iron, steel, and mercury, mirrors, gongs, clocks, varnishes, laquers, vegetable and animal waxes, paper, engraving and printing, textile fabrics, agriculture, the cultivation and manufacture of tea, sugar, rice, indigo, the food of the natives, and many other items, the mere enumeration of which would extend this notice to a greater length than our space will admit of.

We can only recommend our readers to a careful perusal of this very interesting work. The right of translation is reserved, but we should be glad at an early date to hear of an English translation.

The other works received are:—

2. *Guide pratique d'Agriculture générale, par A. Gobri, Professeur de Zootechnie, ancien Directeur de Colonie agricole pénitentiare, Membre Correspondent de la Société d'Agriculture d'Orleans, &c.*
3. *Guide pratique de l'Ouvrer, par M. A. Ortolan, Mecanicien en chef de la Flotte, avec la Colloboration de MM. Bonnefoy, Cochey, Dinée, Gebert, Guipont, Juhel, Mécaniciens de la Marine, ex-éleves des Ecoles d'arts et Metiers.*

We shall merely acknowledge the receipt of the two latter exceedingly useful and most excellent works; but want of space compels us to reserve our review of them till next month.

## Obituary.

### THE LATE MR. JOHN ELDER.

We most sincerely regret having to chronicle the death at a comparatively early age of the eminent shipbuilder and engineer Mr. John Elder. The deceased gentleman was only forty-five at the time of his death, which took place on the 17th of September last.

Mr. Elder appears to have belonged to a race of engineers, his father, Mr. David Elder, having obtained a world-wide reputation as manager of Mr. Robert Napier's works, while both his brothers are also engineers. The subject of our present notice was the second son of Mr. David Elder, and was apprenticed to his father while at Mr. Napier's, where he had the opportunity of learning his profession. Here he soon distinguished himself by his aptitude and his high capacity for practical mechanics, combined with an enthusiastic love of his profession. It was while at Mr. Napier's he had the opportunity of assisting in the designing and construction of many of the finest ocean steamers then built, amongst which may be mentioned the celebrated Cunard liners. Mr. Elder, however, was not content to remain an employé, even in such a large firm, but was anxious to become a principal, so that he might have free scope for his splendid talents. He therefore entered into partnership with Messrs. Randolph and Co., who at that period had not turned their attention to marine engineering; but after that time the new firm of Randolph, Elder, and Co. soon commenced to build marine engines, and by degrees, as a natural outgrowth, the business of shipbuilding was also undertaken.

It was during this time that Mr. Elder, in conjunction with Mr. Randolph, brought out a series of improvements in marine engines and boilers, chiefly directed towards those important points in marine engineering—economy in the consumption of fuel and in space. For this purpose compound engines and vertical cylindrical boilers with high pressure and superheated steam were introduced. As our readers, however, have only to turn to the back volumes of the Artizan to find complete descriptions of these improvements, it is needless to recapitulate them here. It was only about a year ago that Mr. Elder startled the officers of our navy by designing a circular ironclad turret ship, a full description of which has also appeared in the Artizan. About a year ago Mr. Elder's partner retired, leaving him single-handed to carry on one of the most—if not *the* most—gigantic businesses of this description in the world. Scarcely, however, had he arrived at the height of his ambition when a serious illness—abscess in the liver—compelled him to retire from active life and try to obtain benefit by visiting Harrogate. Finding no relief from the waters there, he came to London to procure the best medical advice, but, alas! it was of no avail. Mr. Elder's funeral is said to have been the most impressive spectacle ever seen in Glasgow. About 1,500 engineers and 38 carriages in front, and about 2,000 shipbuilders behind, besides the whole route to the Necropolis being lined with people, gave sufficient evidence of the esteem in which he was most deservedly held.

We are compelled to defer until our next publication a more extended biographical sketch of the late Mr. John Elder, especially in relation to his scientific career.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

**Conservation of Wood by Solutions of Salts of Copper.**—M. Morin states that he has in his possession wooden water-wheels which have been in use for more than 1,500 years for the evacuation of water from a copper mine. These wheels have a diameter of 6 metres; and on a portion of the wood being analysed by M. Payen, it was found to be perfectly sound, and to be partly converted into a compound of cellulose and copper, precisely similar to that which is formed in Boucherie's process for the preservation of wood by sulphate of copper.

**The "Iron Blacksmith."**—A Steubenville mechanic named Wm. Kenyon has invented and has now in operation in that place, a *very* marvellous piece of mechanism, which he styles the "Iron Blacksmith." It occupies the space of an ordinary sized cask, is very compact, is driven by an engine of herculean strength, and the machine itself is of almost incalculable power. It is at present constructed for the manufacture of wrenches used by machinists, gasfitters more particularly. These wrenches are produced from solid steel, at the rate of one every three seconds, doing the work in three seconds which would require the swiftest and most expert workman a whole day to do, besides executing the work much better. When the "Iron Blacksmith" is "fully armed and equipped," it will produce, as if by magic, any description of tool or implement; also, chains, horseshoes, fingers for mowers and reapers, all with the same facility and exactness; in fact, almost every article which now comes from the stalwart blows from the arm, and directed by the mental skill and ingenuity of the intelligent smith. This machine, which is the result of many years of thought and labour, besides an expenditure of many thousands of dollars, is destined to revolutionise the smithing trade.—*Sharon Times.*

**Scientific Education for Artisans.**—A meeting called by the executive committee of the Yorkshire Board of Education has been held in the Civil Court of the Leeds townhall, for the purpose of explaining to artisans and mechanics the Government scheme of scientific education. The mayor was in the chair, and several gentlemen interested in the welfare of the classes proposed to be influenced, including Mr. Carter M.P., and the vicar, were present. Resolutions were passed affirming the necessity of special scientific instruction if the manufacturing superiority of this country is to be maintained, approving of State aid to this scientific instruction, and pledging artisans and mechanics to use their best exertions to promote the object in view.

The Council of the Society of Arts offers its silver medal for the best instrument, to be affixed to a cab or other hackney carriage, for indicating the fare as between the passenger and the driver, whether by registering the distance travelled or otherwise, and which instrument shall also indicate, for the convenience of the cab-owner and of the driver, the total distance travelled during the day and the total amount earned. The instruments competing, with full descriptions of their construction, to be sent to the society's house before the 1st January, 1870. Competitors may, at their option, sign their communications, or may forward with them sealed letters containing the name and address of the writer.

**Production of Copper.**—The 157,335 tons of copper ore produced in the United Kingdom in the year 1868 came from 152 mines; 101 in Cornwall produced 86,722 tons; 20 in Devonshire, 30,540 tons; 6 in Cheshire, Lancashire, &c., 16,569 tons; 9 in Wales, 8,322 tons; 2 in the Isle of Man, 462 tons; 5 in Ireland, 13,890 tons; to which must be added regulus, precipitate, and sundries, 830 tons. The total is rather less than in the preceding year. The quantity produced and the price have been declining for several years. In 1859 the quantity was 236,789 tons, of the value of £1,506,835; in 1868, 157,335 tons, of the value of £642,103. The quantity of metallic copper obtained in the United Kingdom in 1868 was 9,818 tons, of the value of £761,602; in 1859 it reached 15,770 tons, of the value of £1,734,700. In 1868 5,726 tons were obtained from mines in Cornwall, 1,942 tons from mines in Devonshire, 275 tons from Cheshire, Lancashire, &c.; 499 tons from Wales, 28 tons from the Isle of Man, 1,300 tons from Ireland, 48 tons sundries. Of the whole 157,335 tons of copper ore produced in 1868, more than a third came from six of the 152 mines—the Clifford Amalgamated, West Huel Seton, South Caradon, Marke Valley, and Huel Seton in Cornwall, and the Devon Great Consols, which alone produced more than 20,000 tons. The total quantity of British and foreign copper ores and regulus, &c., smelted, and of copper produced, in England and Wales was 485,856 tons of ore and regulus, and 38,137 tons of copper. This last item is constituted thus:—From copper ores of the United Kingdom, 9,818 tons; regulus and precipitate, 340 tons; colonial and foreign ores, 14,229 tons; ditto regulus and precipitate, 9,500 tons; pyrites producing copper, 4,250 tons.

### RAILWAYS.

The Varna Railway Company have received official intimation that the Turkish Government have sanctioned the payment of the guarantee upon the capital actually expended, leaving to arbitration the question whether the Porte is liable for the guarantee upon the whole of the nominal capital, thereby confirming the statements made at the general meeting of shareholders on the 30th September with reference to the recent negotiations of the secretary at Constantinople.

An American paper says that the contractor for the erection of the railway bridge over the Missouri river, which is intended to connect the Missouri and Iowa railroads directly with the Union Pacific, is said to have received notice from the Irish labourers of that locality that he will not be allowed to employ Chinamen on the work. He has, nevertheless, made contracts in California to obtain Chinese labourers, and he intends to bring them to Omaha soon. It is very probable that we shall soon hear of some fighting.

The Belgian Street Railways Company state that they have now nine lines of omnibuses at work, and that 171 journeys out and back are made daily. During the first month of working the receipts were 8,542f., and the expenditure 7,961f. During the month of September the receipts were 25,961f., and the expenses 19,735f. Land has been purchased for the erection of workshops and stables, and arrangements are being made for proceeding with their construction. The concession granted by the Belgian authorities has been extended from nineteen to forty years.

## LAUNCHES.

On the 6th ult Withy, Alexander, and Co. of Middleton Shipyard, Hartlepool, launched an iron sailing vessel of the following dimensions:—Length 110ft., breadth 25ft., depth 14ft. Her register tonnage is 289 tons, and dead weight capacity 450 tons. She was christened *Marquinesa*, and is built to the order of a Spanish firm.

## DOCKS, HARBOURS, BRIDGES.

Messrs. W. Walker and Co. have become proprietors of the Limehouse Dockyard, lately in the occupation of Messrs. Young, Son, and Magnay, and the premises were opened on the 12th ult. for the reception of vessels.

Proposed Wet Dock at Whitehaven.—At a special meeting of Whitehaven Town and Harbour Trustees, Mr. Stiven, the harbour engineer, laid before the trustees a plan for the construction of a wet dock in the harbour of Whitehaven. The situation of the proposed dock is thus described in Mr. Stiven's report:—One of the dock walls will run parallel with Tangier-street. The length of this wall will be 570ft. The wall at the west end of the dock will be 330ft. long, and intersects the bulwark. The front wall across the north harbour will be 560ft. in length, and 70ft. in width. Through this wall and adjoining the present north wall, will be placed the dock entrance-gate, 50ft. in width. The wall at the east end of the dock will be 360ft. long. The area of water space will be nearly four acres and a half. The meeting received the report and resolved that it be printed and circulated, and that Mr. Stiven prepare an estimate of the cost and the probable time that would be required to carry out his plan.

## TRIAL TRIPS.

Trial Trip of the Hindostan.—The new screw steamship *Hindostan*, built and engined by Messrs. C. A. Day and Co., of the Northam Ironworks, at Southampton, for the Peninsular and Oriental Company, has been tried at Stokes Bay for her speed on the measured mile. There was a moderate easterly breeze blowing, with a smooth sea, the barometer standing at 30.35. The true mean speed attained was 14·392 knots per hour, with 30lb. pressure of steam, vacuum 21, and the engines making 55 revolutions per minute. The engines, which are of 600-horse-power nominal, indicated 3,194 during the trial. She had on board a total weight, of coals, water, and stores, of 734 tons, and her draft of water was 16ft. 2in. forward, and 17ft. 8in. aft, the mean draught being 16ft. 11in. The machinery worked with the greatest ease throughout the day, and all on board expressed the most perfect satisfaction with the successful result of the trial. The following are the leading dimensions of the *Hindostan*:—Length between perpendiculars, 349ft. 10in.; length on loadwater line, 344ft. 4in.; length over all, 382ft. 8in.; breadth moulded, 42ft. 3½in.; depth of hold, 33ft.; tonnage, builders' measurement, 3,086 tons; and engines of 600-horse power. She has accommodation for 176 first and 55 second-class passengers, and will be able to carry 800 tons of coals and 1,400 tons of cargo. The hull of the vessel is built with the best Staffordshire iron below the water-line and steel above, and every part of the ship bears unmistakable evidence of the excellence of the materials and workmanship employed in her construction. The *Hindostan* was in charge of Captain Robert Curling, who is appointed as her commander, and she will shortly be despatched to India, where she is to be employed in the company's mail service.

Steam Shipbuilding on the Clyde.—The *Cumbrae* screw, lately built and engined by Messrs. W. Simon and Co., Renfrew, has made a satisfactory trial trip, having attained a speed of about 12½ nautical miles per hour. The *Cumbrae* is the property of the Clyde Shipping Company, and will form one of their South of Ireland steamers. The dimensions of the *Cumbrae* are as follows:—Length, 297ft.; breadth, 27ft.; depth, 15ft.; burden, 620 tons. She is propelled by a pair of direct-acting, inverted-surface—condensing engines of 130-horse power, nominal.

## TELEGRAPHIC ENGINEERING.

The prospectus has been issued of the British-Indian Extension Telegraph Company to construct the first important link of the communication between India and our Australian colonies. This will consist of a cable of 1,756 miles between Ceylon and Singapore, the capital for which will be £460,000, in shares of £10. A contract has been made with the Telegraph Construction and Maintenance Company, who are to complete the work in the course of the coming year for £440,000.

## ACCIDENTS.

A boiler exploded on 19th ult, at Bramley's foundry, Accrington. Some adjacent buildings were demolished, and five persons injured, two of whom died during the day. The boiler, it is stated, was not a large one, and was generally worked at 40lb. pressure, though it was considered safe to work it at 50lb. Steam was a little over 40lb. when last observed by one of the workmen before going to breakfast, and it is conjectured that the steam kept rising, and that over pressure was the cause of the explosion.

Bursting of a Steam Boiler.—Nineteen persons have been killed and nearly a hundred injured by the explosion of a boiler at the State Fair, Indianopolis, in the United States. The boiler was attached to a saw-mill, and had just been fired up for test with another machine, arrangements having been made to take it up as soon as the trial was over. Many of the bodies were horribly mutilated and burned, and in some cases it would be impossible for friends to recognise them.

## STEAM SHIPPING.

Steam Vessels.—An official return shows that down to the 1st of January, 1869, there had been registered at the ports of the United Kingdom 2,918 steam vessels, their aggregate registered tonnage being 904,191 tons, and their gross tonnage 1,341,106 tons. The date of build ranges from 1823 to 1868; the oldest is the *Ann* and *Jane*, of Newcastle, of 27 tons. The list of the names is a loyal list. Three vessels bear the name *Her Majesty*, 16 that of *Victoria*, and there are 12 *Queens*, four *British Queens*, 11 *Princes of Wales*, seven *Alberts*, eight *Alexandras*, and name-sakes of other members of the Royal House. There are two *Dagmars*, and two *Denmarks*. Our own country finds upon the waters 10 *Albions*, three *Anglias*, an *England*, five *Cambrias*, 10 *Britannias*, a *Great Britain*, three *Caledonias*, seven *Scotias*, five *Erins*, three *Hibernias*, three *St. Patricks*, and a *Brian Boroimhe*. Then there are four *Britons*, a *True Briton*, a *Scotchman*, and an *Irishman*. Of birds and beasts and fishes we have three *Hawks*, a *Sea Hawk*, a *Sea Swallow*, seven *Lions*, eight *Tigers*, three *Camels*, five *Bulldogs*, four *Bees*, two *Bats*, six *Dolphins*. Heroes of sacred and profane story are represented. There are ten *Samsons*, five *Ajaxes*, three *Apollos*, two *Catos*, one *Tubal Cain*, besides three *Ariels*, four *Fairies*, and four *Fairy Queens*. Lords and ladies of high and low degree have given their names to our ships; dukes and earls, *Paul Jones* and *Paul Pry*, *Anne Smith* and *Susan Gibbs*, *Kates* and *Nelly's Galileo* and *Euclid*. There is one *Bridegroom*, but two *Brides*; one *Nun*, and last, not least, an Irish steamer, *Number One*.

## LATEST PRICES IN THE LONDON METAL MARKET.

|  | From |  |  | To |  |  |
|---|---|---|---|---|---|---|
|  | £ | s. | d. | £ | s. | d. |
| **COPPER.** |  |  |  |  |  |  |
| Best selected, per ton | 76 | 0 | 0 | " | " | " |
| Tough cake and tile do. | 73 | 0 | 0 | 74 | 0 | 0 |
| Sheathing and sheets do. | 77 | 10 | 0 | 78 | 0 | 0 |
| Bolts do. | 78 | 0 | 0 | " | " | " |
| Bottoms do. | 81 | 0 | 0 | 82 | 0 | 0 |
| Old (exchange) do. | 65 | 0 | 0 | " | " | " |
| Burra Burra do. | 76 | 0 | 0 | 77 | 0 | 0 |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** |  |  |  |  |  |  |
| Sheets, per lb. | 0 | 0 | 9 | " | " | " |
| Wire do. | 0 | 0 | 8 | " | " | " |
| Tubes do. | 0 | 0 | 10½ | " | " | 11½ |
| Yellow metal sheath do. | 0 | 0 | 6¾ | 0 | 0 | 7 |
| Sheets do. | 0 | 0 | 6¾ | " | " | " |
| **SPELTER.** |  |  |  |  |  |  |
| Foreign on the spot, per ton | 19 | 15 | 0 | " | " | " |
| Do. to arrive | 19 | 15 | 0 | " | " | " |
| **ZINC.** |  |  |  |  |  |  |
| In sheets, per ton | 26 | 0 | 0 | " | " | " |
| **TIN.** |  |  |  |  |  |  |
| English blocks, per ton | 123 | 0 | 0 | " | " | " |
| Do. bars (in barrels) do. | 124 | 0 | 0 | " | " | " |
| Do. refined do. | 130 | 0 | 0 | " | " | " |
| Banca do. | 125 | 0 | 0 | " | " | " |
| Straits do. | 125 | 0 | 0 | " | " | " |
| **TIN PLATES.*** |  |  |  |  |  |  |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 2 | 6 | 1 | 3 | 0 |
| IX. do. do | 1 | 8 | 6 | 1 | 9 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | " | " | " |
| Do. at works do. | 12 | 10 | 0 | " | " | " |
| **IRON.** |  |  |  |  |  |  |
| Bars, Welsh, in London, per ton | 7 | 0 | 0 | 7 | 5 | 0 |
| Do. to arrive do. | 7 | 0 | 0 | " | " | " |
| Nail rods do. | 7 | 2 | 6 | 7 | 5 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 0 | 0 |
| Bars do. do. | 7 | 7 | 6 | 8 | 0 | 0 |
| Hoops do. do. | 8 | 0 | 0 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | 6 | 5 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | " | " | " |
| Do. railway, in Wales, do. | 7 | 5 | 0 | 7 | 10 | 0 |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | " | " | " |
| Pig No. 1 in Clyde do. | 2 | 13 | 3 | 3 | 1 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | " | " | " |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| **STEEL.** |  |  |  |  |  |  |
| Swedish in kegs (rolled), per ton | 14 | 0 | 0 | " | " | " |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 5 | 0 |
| Do. in faggots do. | 15 | 15 | 0 | 16 | 0 | 0 |
| English spring do. | 19 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | " | " | " |
| **LEAD.** |  |  |  |  |  |  |
| English pig, common, per ton | 19 | 0 | 0 | " | " | " |
| Ditto. L.B. do. | 19 | 10 | 0 | " | " | " |
| Do. W.B. do. | 20 | 5 | 0 | " | " | " |
| Do. sheet, do. | 19 | 10 | 0 | " | " | " |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | " | " | " |
| Spanish do. | 18 | 5 | 0 | " | " | " |

* At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

### Dated September 24th, 1869.

2775 J. Faulkner—Exhausting the gas from coal mines
2776 W. H. Hewett—Inscriptions and designs on metal surfaces
2777 B. Hunt—Automatic railway carriage or car brake
2778 W. Strang—Dressing and apparatus for beaming warps
2779 R Collis—Velocipedes
2780 J. H. Davis—Compasses
2781 W. I. Palmer—Paper
2782 G. L. Morton—Stoppering bottles intended to contain effervescing liquids
2783 J. T. Greenfield—Side arm for clearing the rifling of ordnance
2784 J. W. Morgan—Anchors
2785 T B. Daft, E. Axmann, and T. W. Wiliin—Watches

### Dated September 25th, 1869.

2786 I. Farrell—Bearings for axles
2787 W. Harper—Suspending fabrics in drying stoves
2788 J. T. Gaze and J. Hymas—Fire bars
2789 H. A. Bonneville—Greek firearm
2790 J. P. Turner—Fastenings for braces and other articles
2791 J. W. More and J. Norman—Clipping horses and other animals
2792 J. Worrall and J. Kershaw—Folding piece goods
2793 S. G. Archibald—Carding and twisting or spinning oakum
2794 J. C. Cushion—Picks for dressing marble and other stone
2795 J. Stuhrt—Treatment of ores
2796 G. W. Rendel—Gun carriages
2797 G. W. Rendel—Guns

### Dated September 27th, 1869.

2798 T. Hall, J. B. McKerrow, and T. R. Shaw—Effecting the discharge of dye wood from hanks or yarn
2799 C. de Bergue—Utilising the muscular power of man
2800 W. Boulderson—Coverings for the head
2801 F. W. Fox and E. Walker—Steam engines and their boilers
2802 J. Peel, J. Sharp, and J. Walworth—Looms for weaving
2803 G. Beunie—Oils
2804 J. Hastie—Applying heat and obtaining motive power
2805 R. Harlow—Valves
2806 E. O'Brien—Weighing grain and other substances
2807 G. T. Bousfield—Sized paper
2808 J. R Swann—Boiler tubes
2809 J. R. Wigham—Illuminating buoys, lighthouses, &c.
2810 T. R. and T. W. Harding—Leather driving bands
2811 W. E. Newton—Lappet or embroidering looms
2812 W. Kendal—Furnaces
2813 F. Armstrong—Knitting machine

### Dated September 28th, 1859.

2814 W. Chambers—Ventilating
2815 J Taylor—Brad awls
2816 W. Whiteley—Spinning cotton and other fibrous substances
2817 R. and H. Harrild—Manufacture of printing rollers
2818 C. D. Abel—Green colouring matter for dyeing or printing
2819 J. Buchanan—Substitute for soda crystals or refined ash
2820 J. Bullough—Looms
2821 H. Swan—Millstones
2822 J. W. Billiatt—Elevators
2823 H. Y. D. Scott—Kilns
2824 A. V. Newton—Horseshoe nails
2825 W. R. Lake—Preventing alteration of values in monetary instruments
2826 W. R. Lake—Harvesting machines

### Dated September 29th, 1869.

2827 W. H. Noble—Aerial carriage
2828 A. J. Dulake—Pot for containing butter, lard, &c.
2829 J. Williams—Lifting jacks
2830 W. Walker and D. Davies——Furnaces for steam boilers
2831 W. Blunn and J. Wild—Melting material from which glass is made
2832 D. Duthie—Tenoning timber
2833 L. Wray—Crushing stone and other hard substances
2834 W. and A. Kempe—Scrays or tables applicable to gig mills
2835 H. Hughes—Rolling or reducing rods, bars, or tubes

### Dated September 30th, 1869.

2836 A. F. Wilson—Utilising waste heat
2837 J. Anderson—Separating the constituents of maize
2838 J. P. Kerr and W. McGee—Winding thread upon pirns
2839 H. Woolf—Hat brims
2840 W. Horton—Steam boilers
2841 J. Reeves—Bearings of the wheels of velocipedes
2842 A. E. Fridlander—Watches and chronometers
2843 J. Lund and E. Townend—Self-acting apparatus applicable to carriages
2844 A. Gaine—Knobs for doors and other similar objects
2845 G. Hinton—Combined water power
2846 J. Dewe—Locks

### Dated October 1st, 1869.

2847 H. L. Bolger and J. Meekin—Splitting rocks and other masses
2848 R. Crickmer—Preventing priming in steam boilers
2449 F. S. Barff—Absorbing noxious vapours and gases
2850 J. Bonn and J. Nitsch—Ruling lines on paper and other substances
2851 J. H. Johnson—Screws
2852 E. A. A. Hugo—Leather
2853 R. L. Hickes—Construction and fitting of fire arms
2854 G. A. Huddart—Joining or fishing the rails of railways
2855 W. R. Newton—Sewing machines
2856 A. J. Eli and H. Sawahn—Registering distances

### Dated October 2nd, 1869.

2857 G. S. and H. Whitechurch—Stoves and fireplaces
2858 J. Butcher—Pens
2859 A. Bodart—Ascertaining the specific gravity of liquids
2860 W. Edmondson—Engraving cylinders used for printing
2861 T. Buck and G. Messenger—Writing instrument
2862 E. Ludlow—Cartridges
2863 A. Keen—Buckle for fastening hoops around bales of goods
2864 C. A. Mangin—Silvering looking glasses
2865 E. D. Farcot—Construction and propelling of ships
2866 R. Broadheut—Gas governors
2867 A. Heathorn—Yeast
2868 J. Reid—Waterproof coats
2869 B. F. Stevens—Covering, lighting, and ventilating areas

### Dated October 4th, 1869.

2870 P. R. Hodge, C. Hengst, and N. Wilson—Welding of iron
2871 J. A. Hartmann—Engraving
2872 F. Grau—Lamp sockets
2873 J. Critchley—Umbrellas
2874 G. Rose—Annealing pots
2875 Sir C T. Bright—Telegraphs
2876 C. Mather and W. Rosseter—Warping or beaming machines
2877 F. R. A. Glover—Anchors
2878 F. F. Villepigue—Piercing or boring holes in rocks, &c.
2879 J. B. Bradshaw—Coopers' hoops

### Dated October 5th, 1859.

2880 C. Montagu—Umbrellas
2881 T. Atkinson—Expressing oil
2882 W. Horsfall—Forging bolts
2883 J. N. Batey—Hemmers for sewing machines
2884 J. Winter—Filling glass bottles and jars with soups, &c.
2885 F. Hazeldine—Corkscrew
2886 W. Morris and J. Teal—Combing wool
2887 L. Byrne—Pumps
2888 H. Howard-Keeling—Manufacturing bars of wrought iron
2889 T. W. Bunning and W. Cochrane—Getting coal
2890 J. Kircher and E. Ehner—Black printing ink
2891 J. Kircher and E. Ehner—Removing print from paper
2892 E. Smethurst—Funnels for pouring liquids into vessels
2893 T. Adams—Slide valves
2894 J. Clayton—Construction of boilers for generating steam
2895 W. Richardson—Cleaning cotton and other fibrous materials
2896 C. E. Spooner—Bending rails or bars for railways

### Dated October 6th, 1869.

2897 S. Farren—Taps
2898 E. Wigzell and J. Pollit—Pistons
2899 W. A. Whitty—Advertising medium
2900 J. W. Powell—Valve cock
2901 B. Hunt—Decoration or ornamentation of metals
2902 H. and A. Holmes—Axletrees
2903 W. R. Lake—Permanent way of railways
2904 E. Russ, and H. and E. Hammond—Breech-loading firearms
2905 T. F. Newell—Engines for preparing paper pulp
2906 E. A. Pontifex—Refrigerators
2907 E. Tyer—Telegraphic signalling on railways
2908 W. H. Horsley—Washing machines
2909 E. B. de Leon—Printing without heat upon wood
2910 W. E. Newton—Permanent way of railways and tramways
2911 J. F. M. Pollock—Bricks

### Dated October 7th, 1869.

2912 J. McKenzie—Securing the rails in railway chairs
2913 A. and W. Coleman—Latches
2914 J. C. Ramsden—Looms
2915 H. Schildberg—Signalling
2916 W. E. Newton—Propelling ships
2917 W. P. Gregg—Parlour skates

### Dated October 8th, 1869.

2918 R. Chapman—Fastening railway fish plates and chairs
2919 D. Parrish—Axle boxes
2920 J. Hilton—Casting pipes
2921 J. Duckword, T. Hindle, and G. B. Jerram—Cement buildings
2922 G. W. Hawksley and M. Wild—Steam boilers
2923 W. R. Lake—Pianoforte pedals
2924 T. Rice—Fixing door knobs
2925 A. Etienne—Carriages, vehicles, and velocipedes
2926 O. C. Evans—Wheels
2927 N. Wilson and W. Campion—Sewing machines
2928 H. Wainwright—Producing fresh potable water
2920 J. Frearson—Water tuyers for forges and furnaces
2930 J. Wallace—Distilling liquors
2931 W. J. Jones—Boilers

### Dated October 9th, 1869.

2932 C. E. Brooman—Liquid meters
2933 J. Chandler—Preventing waste of water from pipes
2934 J. More—Preparation of oils
2935 R. L. Hickes—Applying electricity
2936 W. Kelsey—Driving drums
2937 D. Sowden, R. C. Stephenson, and J. Myers—Looms
2938 B. Baugh and B. Walters—Ornamenting bricks and tiles
2939 J H. Johnson—Nail-making machines
2940 H. Reid—Cements
2941 W. N. Hartley—Bleaching yarns
2942 A. H. Braudon—Summer skate
2043 E. H. C. Monckton—Motive power
2944 E. H. C. Monckton—Projectiles
2945 A. M. Clark—Indicators for steam boilers
2846 W. C. May—Painting inks
2947 C. Wyndham—Velocipedes
2948 J. H. W. Biggs—Joining warp ends
2949 A. Welch—Cattle trucks

### Dated October 11th, 1869.

2950 A. C. Kirk—Treating oils
2951 G. A. Middlemiss—Withdrawing water from wells
2952 J. Hugget and J. A. Huggett—Manufacture of nails
2953 E. A. Cowper—Treating cast iron for the production of wrought iron
2954 A. V. Newton—Paper hangings
2955 T. Greenwood and J Keats—Boots
2956 W. R. Lake—Land cultivator
2957 W. R. Lake—Permanent way of railways

### Dated October 12th, 1869.

2958 A. B. Childs—Paper
2959 E. A Snuggs—Cocks and taps
2960 R. L. Hattersley and J. Hill—Looms
2961 T. Cope, J. Hignett, and G Lander—Twisting tobacco
2962 J. B. Blythe—Production of heat
2963 M. Andrew—Locks
2964 W. Rennett and J. Currall—Kitchen ranges
2965 E. Farrington—Firearm
2966 E. Brown—Propelling carriages by the hands or feet
2967 J. Morrison and J. Thomas—Grates of furnaces
2968 T. Stevenson—Iron girders
2969 W. Lincolne—Fastening or securing the joints of belts

### Dated October 13th 1869.

2970 J. H. Selwyn—Firearms
2971 J. Halford—Furnaces
2972 L. M. Casella—Lighting gas burners and lamps
2973 J. Smith—Timing ships' logs
2974 J. Kennedy—Cement
2975 R. Scholefield—Pumps
2976 T. Parry and J. McHardy—Drag applicable to waggons, &c.
2977 S. Osborn—Knives for reaping and mowing machines
2978 W. Challiner—Forks and spoons
2979 C. Brakell—Propelling air
2980 J. Hartley—Registering billiards
2981 R. J. Ellis—Desiccating animal and vegetable matters

### Dated October 14th, 1869.

2982 W. J Bonser—Feeding cattle
2983 W. E. Gedge—Putting up or encasing pockets of needles
2984 J. H. Roberts and E. Simons—Breaks for railway carriages
2985 B. Calvert—Cleaning hose pipes
2986 F M. Cotton and W. Field—Copying of drawings
2987 S. Wilson—Applying power to the knee joint of presses
2988 C. W. Siemens—Smelting iron
2989 L. A. Lesage—Securing vessels containing alimentary substances
2990 E. Lane—Permanent way of railways
2991 C. L. Page—Packing cases
2992 J. Hudson, J. Hudson the younger, and C. Hudson—Paper
2993 W. Kloen—Water colour printing
2994 E. L Parker—Combined corkscrew and carriage key
2995 J. Tait and J. C. Edwards—Opening and preparing cotton
2996 W. Barbour—Stage lights
2997 N Washburn—Wheels
2998 W. Avery and A. FentonCases for pins, cards, &c.
2999 E. Roe—Knitted fabrics

### Dated October 15th, 1869.

3000 G. W. Rowley—Combined under garment
3001 D. Brown—Treating iron surfaces
3002 L. Byrne and W. Payne—Packing
3003 J. Mackie—Firearms
3004 W. R. Lake—Boring rocks
3005 W. R. Lake—Sewing machines
3006 W. R. Lake—Chain cable stoppers
3007 S. Barber—Propulsion and steering of ships
3008 J. Walker—Measuring fluids
3009 J. W. Robinson and T. Murray—Burning of liquid carbons
3010 E. T. Hughes—Regulating the delivery of railway tickets
3011 E. T. Hughes—Raising and lowering merchandize
3012 W. B. Leachman and J. Holroyd—Raising water
3013 H. Smith—Dish covers
3014 J. H. and W. Lyon—Furnaces
3015 W. E. Gedge—Horse-shoes
3016 A. H. Douche—Valves
3017 H. M. Marsden—Sheep shears

### Dated October 16th, 1869.

3018 J. Horton—Castors
3019 F. F. Whitehurst—Mashing grain
3020 J. Willats—Playing cards
3021 J. J. Nancy—Supplying thread to sewing machines
3022 A. Angell and J. J. Perry—Heating metal bars
3023 W. H. H. McMeight—Blinds
3024 J. Raper M. Pearson. and D. Mills—Looms for weaving
3025 J. Player—Iron

### Dated October 18th, 1869.

3026 W. Rogers and G. Tidcombe—Croquet balls &c.
3027 N. Hodson—Motive power engine
3028 J. M. A. Stron—Clocks
3029 G. Collins—Carding engines
3030 J. C. Martin—Name plates for shops
3031 J. and W. Bottomley—Milling woven fabrics
3032 J. and W. Bottomley—Washing woven or felted fabrics
3033 P. Jacques—Purifying and decolouring blood albumen
3034 C. and W. Bradley and E. Thackray—Wool combing machinery
3035 R. S. Bartleet—Needle cases
3036 A. P. Price—Purification of gas
3037 M. Ker—Hanging window curtains
3038 C. E. Spagnoletti—Signalling
3039 A. Welch—Cattle trucks
3040 A V. Newton—Sacking
3041 W. R. Lake—Nut for screw bolts

### Dated October 19th, 1869.

3042 J. and J. Kippax—Weaving counterpanes or quilts
3043 M Henry—Bridges
3044 A. Forder—Velocipede seats
3045 A. Evans—Joining pipes
3046 W. B. Robins—Syringes
3047 A. Clegg—Sewing machines
3048 J. H. Johnson—Heating
3049 F. R. Window—Producing photographs in pigments

### Dated October 20th, 1869.

3050 J. Hudson—Opening and closing the gates of railway crossings
3051 D. Jackson, J. Riley, and G. R. Ray—Cutting stone
3052 W. R. Thomson—Fastening the doors of railway carriages
3053 A. Munro and W. B. Adamson—Cutlery
3054 J. Scharr—Soap
3055 B. Sulman and R. Willis—Stamping and cancelling press
3056 W. Heywood and J. Bottomley—Carriages
3057 J. F. Cresse—Attaching cements to iron substances
3058 A. Brady—Purifying iron
3059 W. Firth—Wheels
3060 J. Howard and E. T. Bousfield—Construction of steam boilers
3061 W. E. Newton—Preserving various substances from decay
3062 H. Percival—Furnaces

### Dated October 21st, 1869.

3063 S. H. Musgrave—Needle cases
3064 H. Brooks—Metallic cap or cover to glass bottles
3065 J. Becker—Stopping bottles
3066 G. M. Ashforth and W. Hardy—Applying motive power
3067 W. R. Lake—Rotary blowing engines
3068 G Clark—Hansom cabs
3069 G. Dauzats—Dominoes
3070 J. Buchanan—Coiling ropes
3071 F. Jenken—Bridges
3072 A. M Clarke—Hinges for the doors of railway carriages

### Dated October 22nd, 1869.

3073 R. J. Goodbody and R. E. Donovan—Roastin coffee, &c.
3074 T. Gibb and C. Geltsharp—Furnaces for calcining ores
3075 H. A. Bonneville—Sewing machines
3076 J. R. Grayson—Clipping or shearing horses and other animals
3077 C E. Fuller—Machines for manufacturing brushes
3078 J. Rignall—Reaping machines
3079 W. J Rivington—Counting and registering apparatus

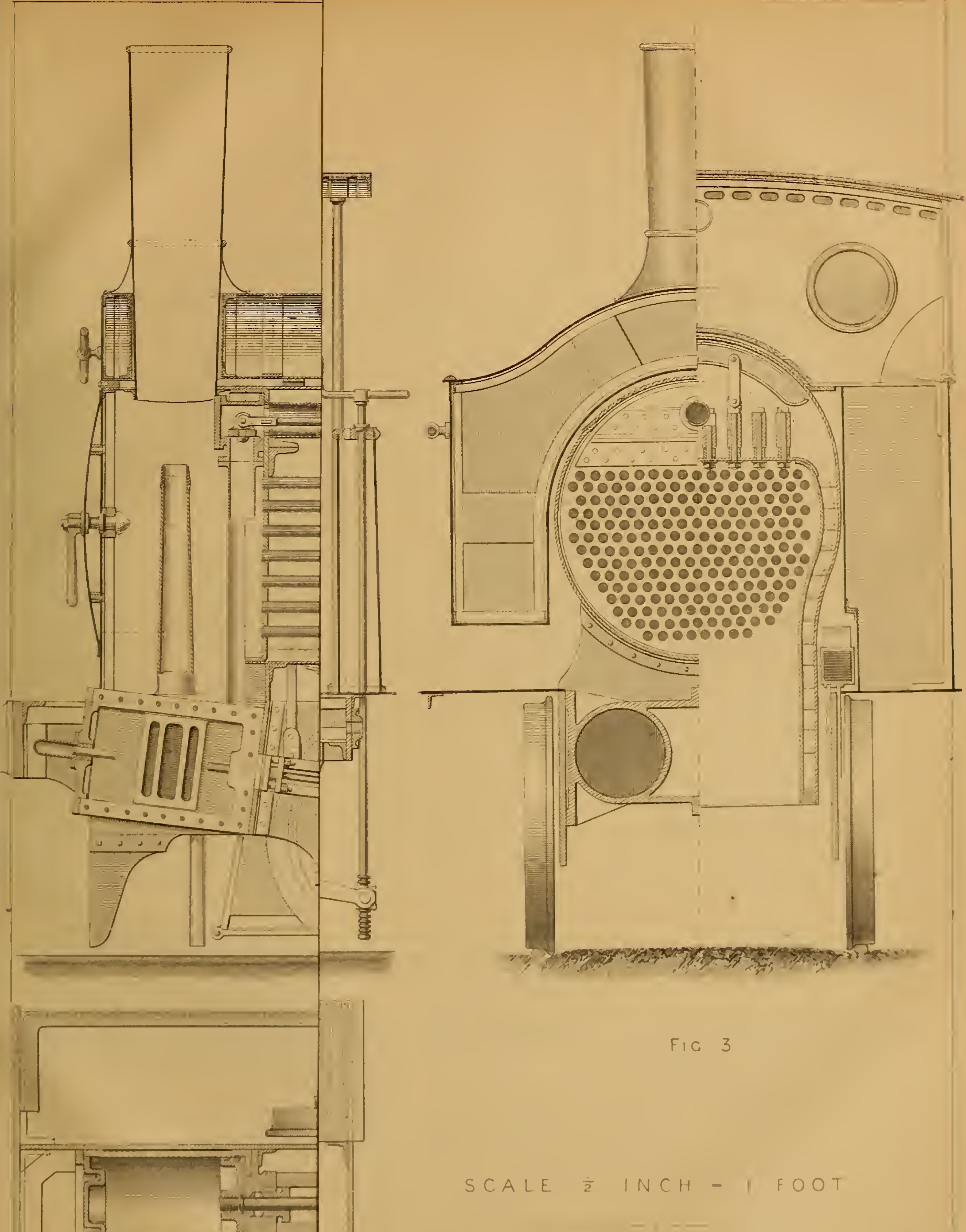


Fig 3

SCALE ½ INCH – 1 FOOT

W. Smith, C.E. direx

# LOCOMOTIVE ENGINE,

FOR Gt WESTERN RAILWAY N S W

DESIGNED BY [illegible]

Fig 1

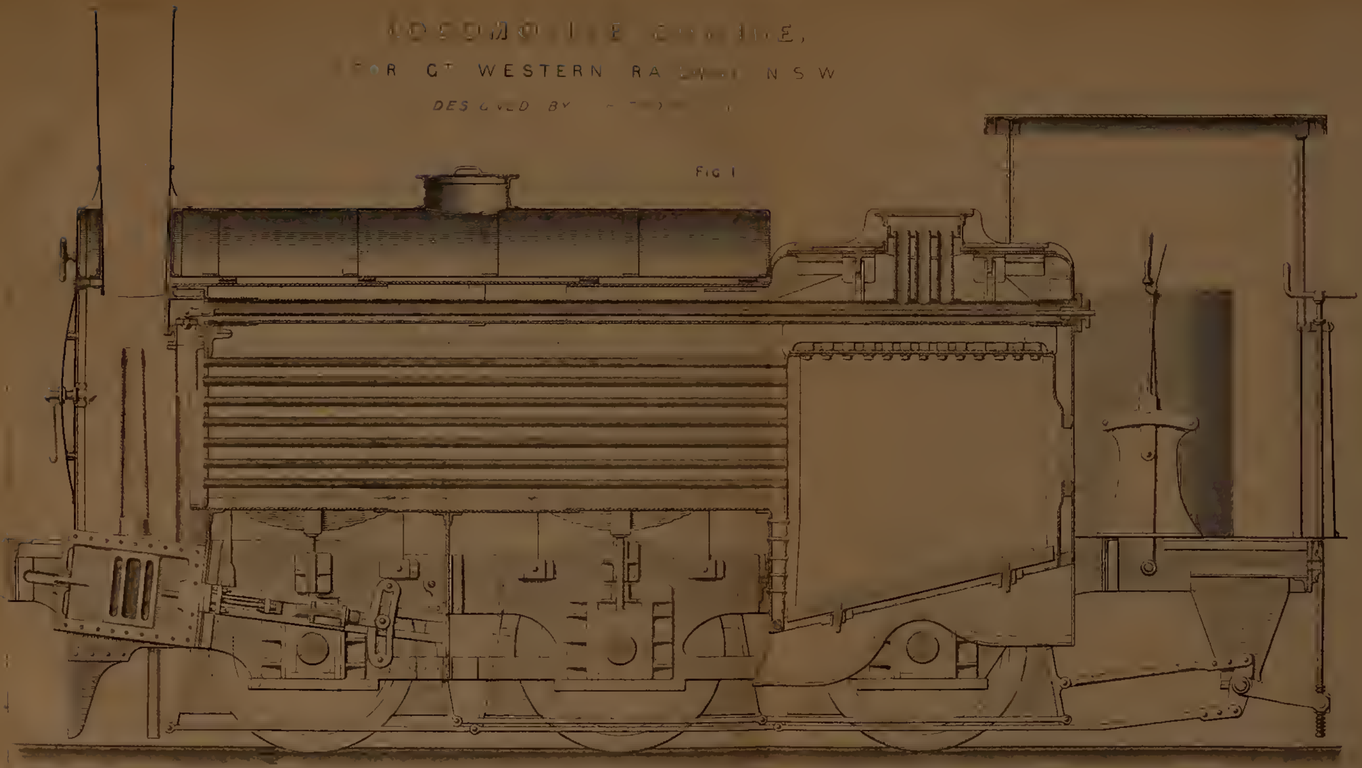


Fig 3

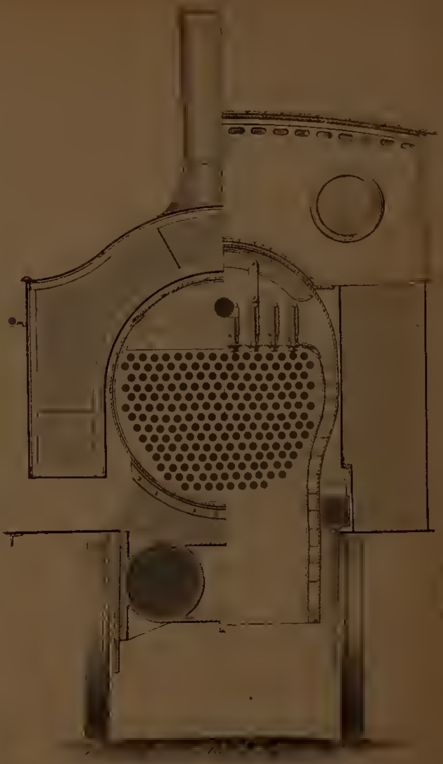
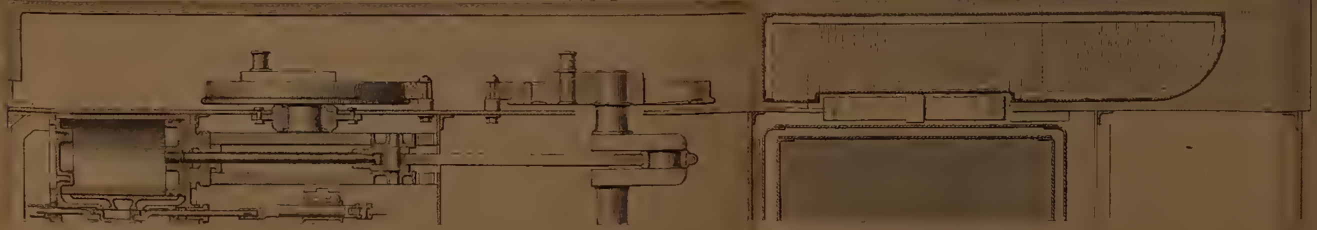


Fig 2



SCALE [illegible] INCH = 1 FOOT

# THE ARTIZAN.

No. 12.—Vol. III.—Fourth Series.—Vol. XXVII. From the Commencement.

1st. DECEMBER, 1869.

## MANUFACTURE OF ROLLING STOCK IN NEW SOUTH WALES.

### Locomotive for Great Western Railway.

(*Illustrated by Plate* 355.)

With the view of encouraging colonial industry, the late Minister for Public Works (the Honourable James Byrnes) determined in future to have all the rolling stock required for the Government railways in New South Wales made in the colony. Hitherto both marine and stationary engines, all classes of machinery, iron and wooden ships, etc., have been constructed in Sydney, where some large engineering establishments have sprung up, one of which alone employs on the average 400 men. Mr. Byrnes, therefore, very naturally considered that the time had arrived when the rolling stock for the 300 miles of line opened for traffic might with advantage be manufactured in the country, and accordingly issued instructions to the Engineer for Existing Lines (Mr. J. H. Thomas, C.E.,) to draw up the necessary plans, general conditions, specifications, and form of tender, to carry out the object in view; and, in order that there should be no mistake, and all persons tendering clearly understand what was required of them, the whole were printed and circulated for general information.

The contracts were made to extend over five years, and the total quantity of rolling stock that would be required during the specified period would be as follows:—

| | |
|---|---|
| Engines | 30 |
| Carriages of different classes | 75 |
| Horse boxes | 40 |
| Carriage Trucks | 40 |
| Break vans | 12 |
| Sheep vans | 50 |
| Cattle waggons | 100 |
| Covered goods' vans | 50 |
| Meal vans | 40 |
| Powder vans | 15 |
| Trucks of various classes | 540 |

Several tenders were received, and two—those of Messrs. Vale and Lacy for the engines, and Messrs. T. N. Russell and Co. for the remaining rolling stock—were accepted.

The Great Western Railway, which is to connect Sydney with Bathurst, crosses the Blue Mountain Ranges, attaining an altitude of 3,800ft. above the level of the sea, necessitating the use of two "zig-zag" gradients of 1 in 30, and curves of 8 chains radius. With such a line as this, as might readily be supposed, the ordinary class of locomotive engines which had been imported from England—well adapted as they were for lines with easy gradients and curves of large radii—were not found suited to this mountain railway. Mr. Thomas was therefore instructed by the Government to prepare plans and specifications of an engine better adapted for the work, two of which are now in course of construction by Messrs. Vale and Lacy, of Sydney.

### Specification of Goods Tank Engines for the Great Western Railway.

The work to be executed under this contract, comprises the supplying and delivering of engines of that class known as six-wheeled coupled tank engines, having the following dimensions:—Diameter of cylinder, 18in.; length of stroke, 24in.; diameter (outside) of boiler, 4ft. 4in.; number of tubes, 196 (more or less); length of do., 11ft. 1in.; diameter of do. (external), 2in.; distance from centre to centre of cylinders, 2ft. 5½in.; from head of frame to centre of leading wheels, 5ft, 8¼in.; distance between centres of leading, driving, and trailing wheels, 5ft. 9in.; wheel base, 11ft. 6in.; from centre of trailing wheel to end of foot plate, 7ft. 3in.; total length of frame, 24ft. ½in.; width between frames (inside measurement), 4ft. 1in.; thickness of frames, 1⅛in.; diameter of wheels, 3ft. 9in.; length of fire box (casing), 5ft. 9in.; do. do. inside, 5ft. 3in.; area of fire grate, 19ft. 3in.; diameter of axle bearings, 7½in.; length of do., 6½in.; ports (cylinder), 14in. by 1⅜in.; exhaust, 14in. by 3½in.; from centre to centre of buffers, 5ft. 9in.; height of buffers above rail, 3ft. 4in.

The boiler is to be constructed of the form and dimensions shown on the drawings (Plate 355), lap jointed, and all the plates used in manufacture must be ⅜in. thick; and both these and the angle irons must be of the very best Low Moor iron, or such other as may be approved of by the Engineer for Existing Lines of Railway.

The rivets to be ¾in. diameter, of the best Yorkshire iron; the lap of plates to be 2¾in. and the pitch, or distance between centres of rivets, to be 1¾in. Great care must be observed that all the plates and angle irons are brought together before any rivets are put in, and that all the holes perfectly correspond with each other. Should any of them not do so exactly, they must be rimered out until perfectly fair one with another, and a rivet made expressly to fit the enlarged opening thus caused. The heads of all the rivets must be properly set up, and all the joints perfectly caulked on both sides, care being taken in so doing that the plates are not injured.

The fire box casing is to be 5ft. 9in. long, and made of half-inch plates of the same quality of iron as that on the barrel of the boiler, and, bent on the edges to a curve of 4in. radius. The rivets and riveting to be performed in the same careful manner, and with the best material as that specified for the other portions of the boiler.

The fire box is to be of copper, 5ft. 3in. long, and to have a tube plate 1in. in thickness; the crown to be ⅝in. and the other plates ½in. The tube plate is to be pierced to received 196 tubes (more or less), of 2in. diameter and the holes must be so set out as to insure a uniform distance between them; and no more chamfer is to be taken off their edges than is necessary to prevent them cutting the tubes. The fire box stays to be made of copper, ⅞in. diameter; those for securing the fire box to the casing, to be placed 4in. from centre to centre. They are to be screwed with a good sharp clean thread, with that portion in the water space turned off. Each stay must fit perfectly tight, with a full thread in the hole as well as on the stay. The holes in casing and fire box must be true to each other, so that the stay through both may be perfectly square. Each stay must be well riveted over on both ends. The boilers to be stayed by gussets and double angle iron at smoke box end, most carefully fixed; crown of the fire box must be secured as shown on the drawings. Four mud-plugs and doors must be placed on the sides of the fire box casing, level with the top of the fire box, two being on each side, and placed alternately with each other. Four at the corners of the casing, immediately above the water space, bosses of which to be forged on, and two in the smoke box, fair with the inside of the bottom of the barrel. In this latter case the plug must be secured directly into the plate without a brass seating. There must also be two lead safety plugs in the top of the fire box. The tubes to be brass, of the best description of metal, 196 (more or less) in number, and No. 12 gauge; they are to be 2in. outside diameter, secured by approved steel ferrules. The ordinary working pressure will be 120lbs., and the boiler must be tested by hydraulic pressure, hot water being employed, to 240lbs.

on the square inch, and afterwards in steam to 120lbs. The smoke box, top, front, and door to be ¼in. thick, the two former to be made of good plate, with a smooth face, and the latter to be made of best Yorkshire iron; the rivets countersunk and filed flush on the outside. Door and fastenings to be made, and a tube plate of the best ⅞in. Low Moor plate; chimney to be 16in. diameter, and made of ¼in. plate flush jointed outside, and welt inside with the top standing 14ft. above the rails, having 3in. taper. Frame bolts of all kinds must be turned and accurately fitted and driven into their places, the holes being rimered out perfectly fair and true to receive them. The ash pan to be constructed of ¼in. plate and 1½in. angle iron; both the front and back ends must be provided with doors of ¼in. plate, hinged by upper edge, and gear to work each from the foot plate. A well is to be formed on bottom by 1¼in. angle iron, riveted all round. The mouth of the blast pipe is to be covered by one of Moriarty's Spark Arresters, with $\frac{3}{16}$ in. spaces at top. The fire bars must be made not only to change with each other, but with other engines of the same class.

All the wheels are to be entirely made of wrought iron; they must be turned and bored, and have key-ways cut strictly to a gauge, that they may all be precisely alike; and each wheel must be drawn on to its respective axle by hydraulic power, hot water being used to expand the boss; all the rims must be correctly turned to one gauge to receive the tires, so that the tires bored for one will fit any of the wheels equally as well on either of the engines. The gauge of railway is 4ft. 8½in. The best steel rolled weldless tires are to be provided from Monk Bridge, Leeds, those on the driving wheels being without flanges; they must be bored out to the exact shape of the rims of the wheels into which they are to be shrunk, and properly secured; they are to be turned, or ground to a template. The axles to be of the very best manufacture, having journals 7in. diameter and 9in. long. Eccentrics to be of cast iron, 5¼in. throw, and to be keyed fast on their places, the greatest possible care being taken before this is done that their correct positions upon the shaft have been ascertained. The eccentric straps and other portions of the gearing to be of the best Low Moor iron, case hardened, and re-cleaned up. The wrought iron-work to be all composed of Low Moor, or of equally approved iron, and got up with the best finish. All the pins must be of shear steel, and hardened. Longitudinal frames to be of the best iron in one plate, 2ft. 10in. extreme depth, and 1⅛in. thick, planed inside. All the holes must be marked and drilled to one template, and rimered out to the exact size given; and every bolt securing the cylinders, stays, &c., to be turned to gauge, fitted, and driven tight into its place. All the bolts must be carefully made, and turned up to the exact size.

When the frames, cylinders, &c., are all bolted and riveted together, and before the boiler and wheels and axles are put into their places, the correctness of all the dimensions, and the truth and accuracy of all the work must be carefully checked by diagonal as well as longitudinal and transverse measurement. The frames must be strictly square and free from cross windings, and the guard-plate perfectly square with the engine in all directions.

The feet and angle irons on every stay, and of every kind, where they bed upon the frames, must be planed perfectly true, and to the exact length required, so that they fit perfectly to their places without setting or twisting; and every hole must be rimered out that it may be perfectly fair throughout, as specified for the frames. No liners or filling pieces will be allowed to make up imperfect work for dimensions. The axle boxes to be of best cast iron, fitted carefully to template both inside for the steps and outside for the rubbing pieces. The steps to be of best hard gun metal, and to be confined by iron boxes underneath the journals. Care must be taken in fixing the oil pipes in the top of the axle boxes, that they be so placed as to convey all the oil directly on the top of the journals, and that it is not wasted by running away between the side of the brass and the inside of the box. The axle box bottoms, or oil cellars, are kept up in their places by bolts as shown. All the steps must be perfectly bedded into their respective axle boxes and well fitted on the journals. The leading and trailing wheel boxes are to have half-inch lateral play, but the driving wheel boxes must have no more space allowed between the boxes and rubbing pieces than just sufficient to allow each axle box to slip readily and freely into its place. The rubbing pieces on horn plates to be of hard and strong cold blast cast iron, correctly fitted.

All the springs must be made of the very best spring steel. Each spring must be tested before being put in its place, by being weighted until the camber has been taken off, and on the removal of the weight the spring is found to resume its original form.

The cylinders to be 17in. diameter, and 24in. stroke placed inside the framing, and inclined as shown, made of the very best iron, perfectly free from honeycomb or any defects whatever; they must be truly bored out, the front and end being bell-mouthed $\frac{3}{16}$ of an inch, so that the pistons may be easily put in their places. All the joints to be planed, turned, or scraped to a true surface, so that perfect joints can be made with a coat of very thin linseed oil laid on with a brush. Each cylinder to be bolted to the frames with 1⅛in. bolts. It is most essential that those as well as all the other bolts should be carefully turned to fit perfectly tight in good true holes. Steam ports, 14 × 1⅝. Exhaust port, 14 × 3½. Lap of valve, 1¼in. outside, $\frac{1}{16}$ inside, lead ⅛in., full travel 5in. The body and plate of the pistons to be of the best toughened cast iron, and the rings of gun metal; the latter must be turned ⅛in. larger than the diameter of the cylinders with a ¼in. cut out of them, and then the two ends brought close together, and returned to the exact diameter of cylinder, and properly fitted with a stop. The weight of the piston must be carried upon the packing rings, and not upon the body of the piston.

All the flat surfaces must be well and perfectly scraped, and made steam-tight. The piston rods to be 2⅝in. diameter, and made of steel. The slide valves to be set with a lead of $\frac{3}{16}$ of an inch, and to be made of the best gun metal. The regulators to be made of gun metal in joints, scraped up to a perfect surface, and the lever that works the valve must fit on without shaking, and work smoothly throughout the whole stroke of the valve. The slide bars to be of steel. The slide blocks to be of cast iron and to have lubricating boxes. The connecting rod to be of the best fagoted iron, and to be bright all over. The boiler is to be fed by a pair of No. 10 Giffard's Injectors. The feed pipes to be of copper, No. 8 wire gauge, and must be brazed on the inside with hard solder, care to be taken that the pipes are so set, that the flanges of the joints come fairly to their places without any spring upon the pipes. The steam pipes to be of copper, No. 14 gauge, and all the flanges must have scraped surfaces. The hand rails to be of iron, 1⅛in. diameter, and secured to saddle tank with brass studs.

The whole of the boiler and fire box to be covered with white pine, well seasoned, in strips of not more than 2½in. wide by 1in. thick, tongued into each other by hoop iron ⅞in. wide, and the whole well and neatly covered by sheet iron, No. 18 wire gauge, and well secured by brass hoops. Two 3½in. safety valves, of Naylor's or Ramsbottom's arrangement, to be placed over the fire box. One glass gauge and three gauge cocks from pattern to be supplied. The whistle to be made of hard brass to pattern. All bolts and nuts must, in every instance, be to Whitworth's standard thread.

The saddle tank, placed over the barrel of boiler, is to be made of $\frac{3}{16}$ in. best sheet iron, stiffened with ties inside, to be well riveted together, and the points of the rivets neatly snapped. The heads of all the rivets must be properly set up; all joints properly caulked. The plates to be riveted together with ½in. rivets. Buffer beams, 1¼in. rolled iron, to be fitted with draw-hooks and chains at both ends of the engines. The buffers to be Corlett's patent. Four sand boxes to be provided with copper pipes, &c., complete. All the working parts to be furnished with perfect means of lubricating. The glass water gauge must be so placed that the lowest visible part of the glass is 3in. above the highest part of crown of the fire box. Lamp-holders to pattern to be fixed as instructed. Cocks to be supplied and fitted for cylinders, blow-off, scum-water, &c. (of which patterns will be supplied); to be of gun metal. The boiler and fire-box casing to have two coats of red oxide paint, previous to having the lagging put on, and the wood with two coats of lead colour. The frames, wheels, tank, and all other necessary parts of the engine to have two good coats of lead colour previous to the filling, which must be done with three coats rubbed to a perfectly smooth surface, and with another coat of lead colour previous to the finishing, which is to be done in the usual way adopted at the Redfern Railway Works.

*General Stipulations.*

Throughout the whole the very best materials and workmanship is to be used in every way equal to the best class of locomotive engines, and the manufacturer will be held responsible for their safe delivery at ——— and for all defects of whatever kind which may arise from imperfect workmanship or material, until they shall have run a distance of (1,000) one thousand miles with proper loads upon some portion of the railway for which they are intended.

The whole of the engines are to be completed, delivered, and set to work entirely to the satisfaction of the Engineer for Existing Lines of Railway within——. The engineer, or any officer appointed by him, shall have full liberty, at all reasonable times during the construction, to examine all material or work which may be intended for them, and to reject the whole or any portion that may be thought necessary; and any so rejected shall immediately be replaced in a satisfactory manner by the contractor, and at his cost. The dimensions figured upon the drawings to be preferred in all cases to measurement by scale. While the foregoing specification sets forth the general detail of the engines, the engineer reserves the option of such modifications as he may find necessary as the work proceeds, so long as the general dimensions are not interfered with, without any claim of extra payment being allowed. The drawings and specification must be taken to explain each other; but should there be any work and materials which may be reasonably and obviously considered necessary for the proper completion of the engines, but which has not been shown on the drawings, or described in the specification, or that may be mentioned or implied in one only, the same must be considered as included in the contract, and the contractor must find whatever may be necessary to complete the engines according to the true intent and meaning of the specification and drawings; and in all cases of defective description or ambiguity, the explanation given by the engineer shall be binding upon the contractor. The engineer reserves to himself the power of making any deviation from or additions to the engines, without invalidating the contract—the value of such deviations, alterations, or additions to be ascertained and allowed for by the engineer, at such rates as he shall consider to bear a due proportion to the other work of the engines, and the value thereof added to or deducted from the amount to be paid to the contractor, as the case may be. In the event of the construction of the engines not proceeding with that despatch which the engineer may consider necessary, or the contractor fails from any cause to proceed in the execution of his contract, the commissioner shall have full power and authority to cancel the contract, as far as relates to the work remaining to be done; and in such case the moneys which shall have been previously paid to the contractor on account of the work executed, shall be taken by him as full payment for all the work done and materials supplied under the contract; and upon notice in writing, under the hand of the commissioner, that he, under the authority of this condition, cancels the contract, being served upon the contractor, or left at his last known place of abode, the contract shall be cancelled, and thereupon all sums of money that may be due or unpaid to the contractor, together with the portions of the engines left unfinished, and all sums of money named as penalties for the non-fulfillment of the contract, shall be forfeited and become payable to the commissioner, and the said portions of the engines shall become and be the absolute property of the commissioner, and with the moneys so forfeited and payable as aforesaid, shall be considered as ascertained damages for breach of contract. The commissioner will afford every facility to parties undertaking this contract, so far as the selling of any stores, for which cost price, with 10 per cent. added, is to be paid, or the loan of any tools he may possess, and which can be conveniently spared at the time, to be charged for as may be arranged. The contractor will have to satisfy himself of the accuracy of the drawings, and lay down a full sized working drawing of the engine, showing all the details. The tender is to include all expenses of removing, delivery, and trials, as well as all the necessary working plans, tracings, &c. If the contractor become insolvent, have his estate placed under sequestration, or shall make an assignment of his estate for the benefit of his creditors, it shall be lawful for the commissioner, without previous notice to the contractor, or to the official, or other assignee, or assignees of his insolvent estate, or to the trustee or trustees under the assignment, to take such of and all portions of the engines, whether completed or not, from the contractor and from the assignees or trustees of his estate, and re-contract with any other person or persons to proceed with and complete the said engines, upon such terms, stipulations, and conditions, as shall be deemed expedient The contractor will be required to provide two approved persons as sureties, to enter with him into a bond to the Commissioner for Railways, in the penal sum of ——— for the proper performances and completion of the contract. The names of the persons proposed by him as sureties, must be stated in the tender, the Commissioner for Railways reserving to himself the power of rejecting such proposed sureties, should he deem it advisable to do so. Should the contractor fail to procure such persons as may be deemed by the commissioner to be eligible sureties, within ——— days from the acceptance of the tender, or should the contractor fail to execute the contract for the due performance of the work, or to execute and to procure the due execution, by the persons so approved of, as sureties of the bond required for securing the due completion of the work to be done under the said contract, within ——— days after the acceptance of such persons as sureties has been notified to him, the commissioner will have the option of, and full power and authority to declare such acceptance to be annulled. Payment will be made on the engineer's certificate ——— as the engines progress, unless same shall become not payable by reason of anything contained in these conditions up to the date specified for the completion of the contract in the proportion ——— of the value of the work satisfactorily executed, and the remaining ——— will be paid after the engineer has certified that the whole of the engines have been completed to his entire satisfaction. The words "or any officer appointed by him" in these general conditions, shall mean any person who may, from time to time, be appointed by the Engineer for Existing Lines of Railway, to supervise the work; and the words "Engineer for Existing Lines" "Engineer," shall mean the Engineer for Existing Lines of Railways for the time being of the Commissioner for Railways.

J. H. THOMAS,
Engineer for Existing Lines of Railways.

## MORTON'S EJECTOR-CONDENSER.

Our readers will remember that at the beginning of this year we gave a Plate and full description of this clever invention. We have now the pleasure of supplementing that account by a report of some interesting experiments made by Professor W. J. M. Rankine on an engine, at Ryesholm Pit, near Dalry, Ayrshire, which is fitted with Mr. Morton's apparatus, and which is as follows:—

### 1.—General Description of the Engine.

The engine on which the following experiments were made is a single-cylindered double-acting horizontal steam engine. It drives a fly-wheel shaft, which, by means of suitable gearing, and a pair of bell-crank levers, works a pair of pumps for raising water from a pit. The work done by the engine at a given speed is thus practically constant. During the experiments an uniform speed of 22 revolutions per minute was kept up; and the indicated horse-power was 21½. The cylinder is without a steam jacket; consequently some heat is wasted through condensation and re-evaporation in the cylinder, which might be saved if there were a jacket. Throughout the experiments the engine was worked at full steam, the admission going on from the beginning to the end of the stroke. The diagrams taken show a fall of pressure at the end of the stroke to the extent of about 3lb. on the square inch, below the initial pressure; and this is one of the effects of condensation in the cylinder. They also show a gradual formation of the vacuum, during the earlier part of the return stroke; and this is an effect of the re-evaporation of water previously liquefied in the cylinder, through the want of a steam jacket. The engine was originally non-condensing, and was converted into a condensing engine by the addition of an ejector-condenser.

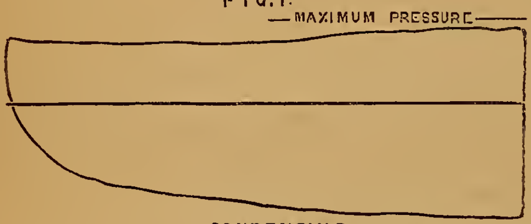
### 2.—Principal Dimensions of the Engine.

| | |
|---|---|
| Stroke | 4½ft. |
| Diameter of cylinder | 18in. |
| Area of piston (allowing for half piston rod) | 252 sq. in. = 1.75 sq. ft. |
| Space swept by piston per revolution | 15.75 cubic ft. |
| Space swept per minute, at 22 revolutions | 346.5 cubic ft. |
| Mean speed of piston, at 22 revolutions per minute | 198ft. per minute. |

### 3.—General Description of the Experiments.

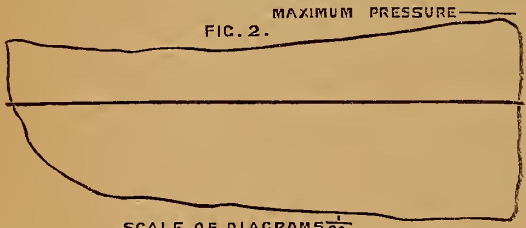
The engine being kept working at the before-mentioned steady speed of 22 revolutions per minute, the quantity of water discharged from the condensing apparatus was measured by means of a suitable gauge; and the rise of temperature of that water was ascertained by comparing together two thermometers, one in the cold well and the other in the hot well. Thus were obtained data for calculating the total expenditure of steam, from its heating effect on the condensation water. Indicator diagrams were also taken to show the power, and the pressure and vacuum in the cylinder when working as a condensing engine. The exhaust pipe of the cylinder was then disconnected from the condensing apparatus, and made to discharge the exhaust steam into the air. The engine was thus made to work as a non-condensing engine, at the same speed and against the same load as formerly; and indicator diagrams were taken to show the pressure in the cylinder under these circumstances. All the diagrams showed the same mean effective pressure, viz., 16.21lb. on the square inch; and the same power, viz., 24 indicated horse-power. The boiler pressure, as shown by the steam gauge, ranged from 29 to 32lb. on the square inch above the atmosphere; but in all the experiments, whether with or without condensation, the pressure in the cylinder was greatly reduced by means of the throttle valve. The vacuum gauge, when condensation was used, remained almost perfectly steady at 24in. = 11.76lb. on the square inch; and this is sensibly identical with the greatest vacuum shown by each of the diagrams.

FIG. 1.



CONDENSING

FIG. 2.



SCALE OF DIAGRAMS $\frac{1}{20}$

NON CONDENSING

FIG. 3.

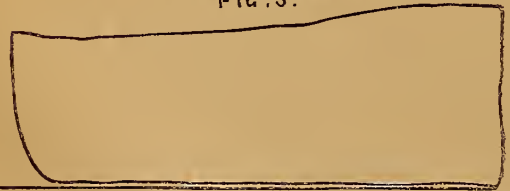
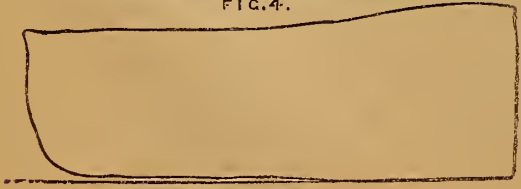


FIG. 4.



### 4.—Experiments made without Condensation.

| | |
|---|---|
| Initial pressure of steam; lb. on the square inch above atmosphere | 19 |
| Final pressure, ditto | 16 |
| Weight of steam expended in lb. per hour, as calculated from final pressure in cylinder | 1578 |
| Ditto, in lb. per I.H.P. per hour | 64·4 |
| Weight of steam expended in lb. per hour, as calculated from initial pressure in cylinder | 1731 |
| Ditto, ditto, per I.H.P. per hour | 70·7 |

### 5.—Experiments made with Condensation.

| | |
|---|---|
| Initial pressure of steam; lb. on the square inch above atmosphere | 9 |
| Final pressure, ditto | 6 |
| Vacuum at the end of exhaust, lb. on the square inch | 11·7 |
| Weight of steam expended in lb. per hour, as calculated from final pressure in cylinder | 1086 |
| Ditto, ditto, per I.H.P. per hour | 44·3 |
| Weight of steam expended in lb. per hour, as calculated from initial pressure in cylinder | 1234 |
| Ditto, ditto, per I.H.P. per hour | 50·3 |

Hence it appears that when the expenditure of steam is computed from the indicator diagrams, it is found to be reduced by the addition of the condensing apparatus to about seven-tenths of its previous amount, when the engine is doing the same work; in other words, the saving is 30 per cent.

### 6.—Result of Experiments on the Condensation Water.

The quantity of water discharged from the condensing apparatus was gauged by causing it to pass out of a tank through an accurately turned and measured circular orifice in a thin plate of sheet iron, and measuring the height above the centre of that orifice at which the surface of the water in the tank stood. The following are the data and results:—

| | |
|---|---|
| Diameter of the orifice, inches | 3·5 |
| Total area, in fractions of a square foot | 0·06682 |
| Effective area, the coefficient of contraction being 0·618 | 0·0412 |
| Head of water in tank | 1½ft. |
| Velocity at contracted vein produced by that head, feet per second | 0·03 |
| Discharge, cubic feet per second | 0·372 |
| " " minute | 22·32 |
| " " hour | 1339·2 |
| " lb. per hour | 83430 |
| Temperature, cold well | 52° Fahr. |
| " hot well | 70° " |
| Difference | 18° " |
| Units of heat (British) per hour given by the steam to the water, very nearly | 1,502,000 |
| Total heat of steam from 52° to 230° (being the temperatures corresponding to final pressure in cylinder) British units | 1,131 |
| Total steam condensed in lb. per hour, as calculated from effect on water of condensation | 1328 |
| Ditto per indicated horse-power per hour | 54·2 |

The excess of the total expenditure of steam as thus computed, above the expenditure as shown by the diagrams, is to be accounted for mainly by condensation and re-evaporation in the cylinder, which go on in all engines not provided with steam jackets.

### 7.—Further Comparisons of Expenditure of Steam.

The calculations of the expenditure of steam in lb. per hour, and in lb. per indicated horse-power per hour, with and without condensation, are here recapitulated:—

| | Lb. Steam per Hour. | Lb. Steam per I.H.P. per Hour. |
|---|---|---|
| *With Condensation.* | | |
| *A.* Calculated from a final pressure as shown by diagram | 1086 | 44·3 |
| *B.* Calculated from initial pressure, as shown by diagram, the fall of pressure during admission being ascribed to liquefaction in the cylinder ... | 1234 | 50·3 |
| *C.* Calculated from effect on temperature of water discharged | 1328 | 54·2 |
| *Without Condensation.* | | |
| *D.* Calculated from final pressure, as shown by diagram | 1578 | 64·4 |
| *F.* Calculated from initial pressure, as shown by diagram, the fall of pressure during admission being ascribed to liquefaction in the cylinder ... | 1731 | 70·7 |

The difference between the numbers marked *B* and *C* in the preceding Table, viz., 94lb. per hour, or 3·9lb. per indicated horse-power per hour, being 7 *per cent.* of the total expenditure of steam marked *C*, represents the quantity of steam lost, or ineffectively expended, through the following causes:—

1. Filling cylinder ports and clearance.
2. Liquefaction immediately on entering the cylinder (followed by re-evaporation during return stroke).
3. Leakage past the packing of the piston.
4. Expenditure at the starting-jet of the condensing apparatus.

It is evident, however, that the first three causes alone are sufficient to account for the whole, or nearly the whole, of a waste of steam amounting to 7 per cent. of the whole expenditure; and this is in accordance with the fact that, during the working of the engine, the cock of the starting-jet is kept so nearly closed that the escape through it must be almost inappreciable, being just sufficient to prevent the suction of air at the small hole in the cylinder of the self-acting piston-valve, by which the starting-jet is regulated.

When the engine was worked without condensation there were no means of measuring the total expenditure of steam, including waste, as there were when condensation was used. If we assume, however, an allowance which is commonly made in practice for clearance, leakage of piston, packing, &c., viz., 5 per cent., we obtain the following *probable* estimate of the total expenditure of steam *without condensation*:—

| | Lb. Steam per Hour. | Lb. Steam per I.H.P. per Hour. |
|---|---|---|
| *E.* Expenditure, as already calculated from initial pressure | 1731 | 70·7 |
| Add 5 per cent. for clearance, leakage, &c. | 87 | 3·5 |
| *F.* Probable total expenditure without condensation | 1818 | 74·2 |
| *G.* Total expenditure with condensation, as before... | 1328 | 54·2 |
| Difference, being net saving by the use of the ejector-condenser | 490 | 20·0 |

Being 27 per cent. of the greater expenditure. This, however, is probably a low estimate of the saving; for it is based on a low estimate of the waste of steam in the non-condensing engine.

### 8.—USEFUL WORK.

The useful work done by the engine is calculated from the following data:—

| | |
|---|---|
| Diameter of bucket of each of the two pumps | 10½in. |
| Stroke | 4ft. |
| Height of lift | 25 fathoms = 150ft. |
| Double strokes per minute, 5-9ths of number of revolutions of engine, or | $12\frac{2}{9}$ |

The results are:—

| | |
|---|---|
| Work, foot-pounds per minute | 550,368 |
| Effective horse-power | 16·68 |
| Indicated horse-power, as already stated | 24·5 |
| Efficiency, or ratio of effective to indicated power | ·68 |

That is to say, 32 per cent. of the indicated power is the power expended in overcoming the friction of the pistons, valves, mechanism of engine and pumps, and pump plungers, and the resistance of pipes and valves to the motion of the water raised by the pumps.

### 9.—CONCLUSIONS.

The principal conclusions to be drawn from the experiments are, that the use of the ejector-condenser effects a saving of steam, as compared with the expenditure of steam by the same engine when doing the same work without condensation, which certainly amounts to 27 per cent., and probably to 30 per cent.; that there is probably a greater proportionate saving in the fuel burned; for it is well known that a diminution in the absolute quantity of fuel burned in a boiler increases the proportionate evaporative power of the fuel, by diminishing the waste of heat: that there is a steady vacuum of 24in. of mercury, or 11·75lb. on the square inch: that the expenditure of steam by the starting-jet is certainly very small, and probably almost inappreciable: that the condensing apparatus is easily manageable, and not liable to get out of order; and that it has been added to the engine without requiring any addition to the size of the engine-house, and without causing any inconvenience by the space which it occupies there.

It may be remarked that the present example of the ejector-condenser, having been originally intended for a larger engine, discharges a quantity of water greater than is absolutely necessary for the condensation of the steam, and therefore at a lower temperature than if the condenser had been specially designed for the engine; and that it therefore does not show the advantages of the ejector-condenser to their full extent.

(Signed) W. J. MACQUORN RANKINE.

Glasgow, September 11, 1869.

## THE "SIN NANZING," NEW PADDLE STEAMER.

The "Sin Nanzing," a new paddle steamer built and engined by Mr. John Elder, Glasgow, to the order of Messrs. Robinows & Marjoribanks for Messrs. Trautmann & Co., of the North China Steam Navigation Company, successfully completed her trials for speed and for economy of consumption of fuel on October 30th. The dimensions of this vessel are:—Length between perpendiculars, 225ft.; beam, 32ft.; depth of hold to spar-deck, 23ft. 3in. Her engines are on the compound principle for which the firm of Randolph, Elder, & Co., have been so long distinguished; they are diagonal, and have four cylinders. The stipulations were, that the speed of the vessel on trial, with 100 tons of dead weight on board, should not be less than 14 knots per hour, on a consumption not exceeding 25 cwt. of coals; and that the speed on a second trial, with 668 tons dead weight on board, should not be less than 10½ knots, on a consumption not exceeding 20cwt. per hour. The first stipulation was successfully performed on Monday, the 25th Oct., the distance being 28 nautical miles. The trial for the second stipulation came off on the 30th of October. The result was, that on a run of upwards of 90 nautical miles, the speed was 10.86, instead of the stipulated 10.5 knots per hour. Besides this, the consumption of coal was only 18¼cwts. per hour, instead of the permitted 20cwts., showing an economy in consumption of fuel over what was required of 9 per cent. Had the whole of the permitted fuel been used, the speed would have been still more in excess of what was stipulated. As it was, the agreed upon premium for the actual excess was won by the builder. Had the "Sin Nanzing" realized only what had been stipulated, it would have furnished another most convincing proof of the correctness and great practical value of the principle of steam expansion, which was introduced by the firm into the construction of marine engines, now some 15 years ago. But, when the dimensions of this vessel are considered, the actual results obtained furnish the strongest demonstration which has yet been given of the immense superiority of the compound engines over those of the common type. During the long period which has elapsed since the time referred to, the firm have devoted their special attention to this branch of their business, introducing from time to time many important improvements. From first to last they have made (including those at present contracted for) no less than 73 sets of these engines, 22 being for paddle, and 51 for screw steamers.

## BOILER EXPLOSION ON BOARD H.M.S. "THISTLE."

The bursting of one of the boilers of this vessel took place under such peculiar circumstances, and was attended with such disastrous results, that something more than what is called "a searching investigation" is required, not only to account for it, but to prevent similar explosions upon the numerous other sister ships to the ill-fated *Thistle*. In order to enable our readers to form a correct opinion of the situation, we may state that the *Thistle* was a twin screw vessel of 465 tons burden, carrying four guns, and of 120-horse power collectively, and was one of a class of vessels lately constructed, under the following circumstances:—It will be remembered that at the time of the Crimean war, a number of high-pressure gunboats of 60-horse power were constructed, and that subsequent experience, notably during their service—or rather their attempt at service—on the coast of China, showed them to be utter failures. The cause of this failure was, we believe, attributed to wretched construction of the hulls of the vessels, which were built at a time when skilled labour commanded something like fourteen shillings a day on the Thames. Although this may, unfortunately, have been the immediate cause of the failure of some of these vessels, there is no doubt but that the design for the machinery was also faulty. We do not mean to say that the workmanship was inferior, for we may say that we never saw it excelled, but that, in spite of the best workmanship, it was impossible to work high-pressure engines with small tubular boilers carrying 60lbs. steam for any length of time in salt water. The fact is salt water and high-pressure do not agree together; this is especially illustrated by the numerous high-pressure boats about the coast of China and the East, which, as far as our experience extends, have never been able to run regularly for three months without repairs. Although, in some cases, as for instance in many of the earlier American engines, the workmanship may have been inferior, most of the engines and boilers are exceedingly well made, and consequently their failure is only to be accounted for by the fact above stated, that it is impracticable to work high-pressure boilers with salt water.

In consequence of the failure of these gunboats, a number of twin screw vessels, of which the *Thistle* is one, have been constructed, a set of engines taken from one of the gunboats, and fitted with air pumps and condensers being used for driving each screw. Their engines are supplied by three new cylindrical tubular boilers with internal furnaces. The boilers, which are 6ft. 1in. in diameter, and the furnaces 2ft. 4¼in. in diameter, were made at Sheerness Dockyard, where it is well known the workmanship is remarkably good.

The only peculiarity about the engines appears to be an arrangement for disconnecting the air-pumps, and working the engines with high-pressure steam, with the blast up the funnel. We cannot understand the advantage of this arrangement, unless it may have been to announce from a distance the approach of such a formidable vessel, and thus give the enemy time to run away.

The *Thistle* was the last boat constructed at Woolwich Dockyard before the closing of that establishment, and having been commissioned, was ordered to make her trial at the Maplin Sands on the 3rd ult. previous to going to her station on the east coast of Africa. After a series of runs with the engines condensing, the steam at 50lbs. in the boilers, and everything apparently in first-rate order, it was determined to try the engines without the condensers and with 70lbs. steam. After making a couple of runs successfully, and while turning for the third, a volume of steam and smoke rushed up the hatchway, telling only too plainly what had occurred. Upon examination afterwards, it was found that the crown of the two furnaces in the middle boiler had both come down, and that the escaped steam had killed nine men, and so severely injured may others, that three have since died.

In order to discover the cause of such a fearful accident, we will give the following extracts from the evidence of scientific men at the adjourned inquest, after premising that the only evidence of consequence at the preliminary meeting was that of Mr. Williamson, Chief Inspector of Machinery afloat, who then said:—"I discovered that that the crown of the furnace (of the midship boiler) was down, which was the same with the other furnace of the boiler. There is no doubt that the breaking down of the crown of the boilers was the cause of the accident." Mr. Williamson, on being re-called at the adjourned meeting, deposed:—"Since the last meeting I have carefully examined the defects in the boiler, with all the mountings attached thereto, and am of opinion that, from its general appearance, the boiler has been short of water, whether from the feed-cock not being kept sufficiently open, or from excessive priming, I am not able to say. In my opinion, deficiency of water was the cause of the rupture in the boiler, but I cannot say whether that deficiency was caused by the feed-cock not being kept sufficiently open, or whether it arose from excessive priming. There is an indicator marked with four degrees, to show how far the feed-cock is open. I have examined the cock since I was here before, and I find that it is one degree open. The other two boilers, which were not all injured, had only the same opening in the feed-cock, and they were sufficiently supplied with water. I have had no report from any one of a deficiency of water in the boiler being observed either before or since the rupture occurred. The boilers are supplied with gauges to show the quantity of water in the boilers. The priming in boilers is generally indicated by the rising and falling and general disturbance of the gauge water-glass, which is seen from the stokehole. If this occurred, the engineer ought to further open the feed-cock and put more water into the boiler, and close the dampers, in order to reduce the draught of air to the fires, so as to reduce the steam."

By the Coroner: In trying these measured miles there is a desire to make the ship go as fast as she will. When a mile is made, a half-turn of the ship is made, in order to run back. Notice is given from the deck when the ship has done her mile, and when she is going on the mile again. This is communicated to the engine-room in order to enable the person at the counter to take the revolutions which the engines make on the mile to stop his calculation at the proper moment. The same communication is made to the engine-room when going on the mile, to enable the same person to recommence his calculation. The half-turn takes some few minutes to make, and during that period the engines are not eased. The half-turn before the rupture took as nearly as possible seven minutes, and the engines were kept at full speed. The speed of the engines is invariably brought up in making the half-turn. The engineer in charge has the power of decreasing the pressure by lifting the valve, but he has no power of decreasing the pressure in the engine-room. That it is quite impossible for him to do, in consequence of the mode in which the lever is fitted. I found on examination that all the fittings to the boiler were in proper order. I do not think it is possible that either a deficiency of water or priming could arise without its being indicated to those in the stokehole.

By the Jury: The proper pressure of steam on this occasion was 70lb. to the square inch, and supposing the pressure indicated in the stokehole was under that point, the pressure might be increased more quickly by a somewhat short supply of water, because the introduction of cold water would rather tend to decrease it. The valve was properly weighted at the time of the rupture. The rupture occurred in the centre boiler, which, being opposite the opening to the engine-room, would have a greater draught, and the steam would possibly be generated more quickly than in the others. That boiler would therefore want more closely watching than the others, and would require a larger supply of water. The water is injected into the boilers by a force pump, but the boiler in question would not require a greater pressure to inject the water than the others.

By the Coroner: I am not prepared to say, indeed I am not able, whether, under the above circumstances, the feed-pipe being one-quarter open was sufficient to keep the boiler properly supplied with water. The feed-pipe is frequently kept less than one-quarter open, the supply of water being regulated by the generation of steam.

Mr. John Boffey, foreman of boilermakers at the steam-engine factory, Portsmouth Dockyard: I was recently removed from this yard to Portsmouth, having been at Sheerness 14 years, and when the boiler in question was made. In 1867 I had an order to make seven sets of boilers of the like description, and the boiler in question was one of them. They were high pressure boilers. It was made under my superintendence. The outside diameter was 6ft. 1in.; the furnaces were 2ft. 4½in. in diameter. The casing or shell was half an inch thick. The plates for the shell were supplied by contract from Messrs. Moser and Sons. The plates for the furnace were from Messrs. Cooper, and were made of the best Yorkshire iron. The tubes were supplied by Russell and Son. The length of the boilers was 16ft. and half an inch, and of the tubes 6ft. and half an inch. On the completion of the boilers they were all subjected to hydraulic pressure, to the extent of 180lb. to the inch. The furnaces were made of Cooper's best Yorkshire iron, tested in the Government establishments before being accepted from the contractor. It was tested in my presence by what we call hot and cold test, which is to try the quality of the iron as metal, and also the tensile strain. The combustion chamber was of the same description of iron, and the tubes of the same, and also the fronts of the boilers. The whole of the materials were subjected to the same test, and everything stood the test satisfactorily. I made an examination of the boilers on board the *Thistle* on Saturday. The two wing boilers are in perfect condition, but in the third or midship boiler I found that one of the furnaces had bulged downwards 14 inches, and there is a fracture also in the upper part of the furnace. The consequence of that was an escape of steam and water, passing through the fire and into the stokehole and engine-room. The boilers were quite new and had never been in use before. Other boilers of a like description have been in use for many months, and have worked satisfactorily. In my opinion the fracture of the boiler was caused by want of water and nothing else. The feed-pipes and all connections are made by the engine-fitters and not by me, and are fixed in the ship. I have had 30 years' experience, and consider the boilers in question were of ample strength to stand any pressure that may have been required of them. I attribute the cause of the fracture to the top of the furnaces becoming red hot for want of water, and thus the strength of the boilers became completely destroyed. The furnaces were 6ft. 9in. in length.

Mr. Andrew Murray, C.B., surveyor of factories, and consulting engineer to the Admiralty, stated: I have examined the boilers of the *Thistle*, and I consider it quite evident that the furnaces of the middle boiler had been red hot from want of water. I further consider that the pressure of steam of 70lb. to the inch would be quite sufficient to cause the tops of the furnaces to come down and be ruptured, and thus allow an escape of steam. I have no hesitation in saying that the boilers were quite equal to the pressure at which they were being worked. I can form no idea how it was that the engineer officer in charge permitted the water to get so low. Mr. Scorer, one of the deceased, and who was in the stokehole, was answerable for seeing that the water in the boilers was kept at the proper height. Mr Roberts, the engineer officer in charge, would, in the course of his duty, look round the machinery frequently, to see that it was in proper order. If the boilers were working steadily and not priming, I should say it would take quite a quarter of an hour to reduce the water in the boiler from its proper level till the furnace tops were bare, as I am satisfied was the case here. The object of trials in ships of war is to test the engines and boilers to the fullest extent possible under proper management. The officers and men employed on the trials are so accustomed to them that they have lost in my opinion, all feeling of racing or extreme excitement, which would induce them to do anything to incur any risk.

By the Coroner: I have known plugs of lead or other fusible metal used in marine boilers, but the custom has been quite abandoned. I consider that to lessen the feed and allow the water to become lower in the boiler will tend to a more rapid generation of steam during the time that the supply of water is diminished; but when that lower level is reached at which the boiler is constructed to be worked, and the proper supply restored, any increased generation of steam ceases. The trials lasted so many hours that the practice of lessening the feed becomes of no value. The working level of water in the boilers was about six inches, and whenever it fell below this it became the duty of the engineer officer in charge of the boiler to take steps to increase the supply of water. The water used on the trial of the *Thistle* was all sea water.

Mr. Lavington E. Fletcher, C.E., was next examined, and stated as follows: I am chief engineer to the Manchester Steam Users' Association for the Prevention of Steam Boiler Explosions. I examined the boiler that exploded on board the *Thistle*, and did so by permission of Mr. Reed, Chief Constructor of the Navy. Having done this, I arrive at the conclusion that this explosion did not result from excessive or improper pressure of steam; neither did it result from any defect in the original construction of the boiler, nor from any defect in its condition at the moment of fracture; but that it arose solely from the overheating of the furnace crowns, in consequence of which the plates composing them lost their strength, and, being unable to resist the pressure of steam, bulged down at the ordinary working pressure. The left hand one rending transversely, for a length of 18in., and two and three-quarter inches at the widest part, thus forming an opening through which the steam and hot water rushed out of the boiler, and playing into the engine-room, scalded to death the men engaged therein. As to the cause of the overheating of the furnace crowns, I have come to the conclusion that the water supply had been overlooked, and thus allowed to run short, when overheating would be inevitable, so that this explosion seems to have been due simply to shortness of water. I should, however, perhaps add that I have met with numerous cases in which furnace crowns have been injured, though certainly covered with an ample supply of water; while in one case a rupture resulted very similarly to that in the boiler under consideration, of which I beg to hand in a sketch. I consider it within the verge of possibility that this rupture might have happened in a similar manner. I think it my duty to call attention to this for guidance in other cases. I cannot in this case give any grounds for the shortness of water, further than by supposing it to have been an oversight. The water in the gauge may give a false reading, if not blown through often enough. I see a difficulty in applying the ordinary fusible plugs to the crowns of marine boilers. I think a new plug recently introduced from abroad by Mr. Black, worthy of consideration, and I may add that it is not attached to the furnace crowns.

Mr. Murray wished to make an addition to his former evidence, and said: I wish to observe that I know of no instance in which the furnace crowns have become overheated when they have been clean and covered with water, either in marine or in any land boilers that have come under my notice.

From the above evidence it will be seen that the scientific witnesses are entirely agreed upon the immediate cause of the explosion, if we except the unlikely idea pointed out by Mr. Fletcher, and which he himself rejects. We must, therefore, take it for granted that the middle boiler was so short of water that the furnace crowns were entirely exposed, while there was plenty of water in both the wing boilers. Unfortunately, we have no evidence as to the particular arrangement for feeding the boilers, and consequently can offer no opinion upon the question as to whether one boiler could rob the other, but must presume that such a contingency had been guarded against. It appears, therefore, that there are but two ways of accounting for it, viz.: either that the water had been allowed to get low by a most unaccountable oversight, or rather a series of oversights; or that the boiler had emptied itself by priming. It is well known to all naval engineers that, the water near the mouth of the river is about the most likely to cause priming, and it is equally well known that urging the fires, as is usual at a trial trip, is another incentive to priming, and also that a new boiler is more likely to prime than an old one. We cannot, therefore, help thinking that the most probable cause of the shortness of water in the boiler was excessive priming, which was not attended to with sufficient promptness.

## THE OPENING OF THE SUEZ CANAL.

The formal opening of this grand work, which took place on the 17th ult., as had been for some months previously agreed upon, was a very imposing spectacle. M. de Lesseps had every reason to be satisfied with his performance, as upwards of forty-five steamers had travelled through the entire distance from Port Said to Suez by the 21st ult., in addition to which an Imperial decree was issued on the 19th ult., appointing M. de Lesseps to the rank of Grand Cross of the Legion of Honour, in consideration of his services.

From the confused telegraphic accounts that have reached us, it is difficult to form a correct estimate, at the present time, of the state of the canal, but it is evident that it cannot be considered nearly complete. So far as we can judge, it appears to be capable of permitting the passage of vessels drawing not more than fifteen feet of water. This will, doubtless, be an immense boon so far as regards light draught steam vessels, but we fear it will take a considerable time to deepen the canal sufficiently to permit large vessels—such as those belonging to the Peninsular and Oriental Company, or their opponents, the Messageries Imperiales—to accomplish a through journey. We are very glad to hear, that in addition to a well merited compliment being paid to M. de Lesseps, by the erection of his statue at Port Said, a similar recognition is to be made of the services of the late Lieut. Waghorn, the original projector of the Overland Route, but who, as is too often the case, derived but little advantage to himself by his indefatigable advocacy of a route which has since proved of such value to the public.

## BRITISH ASSOCIATION.

### A NEW AND ECONOMICAL METHOD FOR EFFECTING THE EXTRICATION AND CONDENSATION OF AMMONIA FROM GAS LIQUOR FOR PURPOSES OF CHEAP CARRIAGE, AND FOR FACILITATING THE MANUFACTURE OF AMMONIACAL SALTS.

By Frederick Braby, F.G.S.

*(Continued from page* 260).

The ammoniacal gas separated by the air is purified in a manner which will be afterwards described, and is then caused to pass into a vessel about three parts filled with broken lumps of pure block ice. From the well-known affinity of ammoniacal gas for cold water, the gas is arrested by the ice, which is rapidly liquefied, and a pure solution of ammonia of any required strength is obtained. It is advantageous to cool down the mixture of air and ammoniacal gas before it is allowed to enter the condenser; the air after having parted with the ammonia which has been dissolved by the liquefied ice, passes off into the atmosphere, as in the former instance. The finest Norwegian transparent block-ice may, in the height of summer, be obtained at the London Docks at 23s. per ton, and even less, according to the number of tons required, the supply being constantly maintained by the arrival of fresh ships. Or ice may be obtained by one of Siebe's refrigerating machines almost as cheaply as that which is imported.

This patent process for separating the ammonia by blowing air through gas liquor, when at an elevated temperature, is so much more rapid in the operation than the process of merely boiling the gas liquor as hitherto conducted that, with a very moderate-sized apparatus, several thousand gallons of gas liquor can be treated in a single day, and the ammoniacal produce of the largest works may be continuously converted into a concentrated and more portable form without trouble or delay. Even in the smallest works, consuming not more than from ten to fifty tons of coal a week, the bulk and weight of the gas liquor may be quickly reduced, and the result will be of such standard value that a still containing from 20 to 100 gallons would, probably, in such cases, answer every desired purpose, and would be found to be remunerative. In many instances the gas liquor might be heated and the power supplied, if desirable, from the waste heat of the retorts.

By the adoption of this improved process the present trade in crude ammonia may be expected to expand and to become of higher importance than it now is.

The comparatively limited supply which is now available restricts its application. The commercial advantages which would be derived from the many technical purposes to which it is applicable would be considerable, and manufacturers being enabled to obtain cheap supplies from distant sources, the total quantity utilised would be immensely increased,

When, instead of producing caustic ammonia it is desired to manufacture ammoniacal salts, the ammoniacal gas in conjunction with the atmospheric air may be conducted into sulphuric or muriatic acid, or into a metallic or saline solution capable of appropriating the ammonia.

As the evaporative power of air increases with the absence of moisture therein, it is possible that, by drying the same artificially before introducing it into the liquor, it would take up a great quantity of ammonia. The removal of all moisture from air may be effected with comparatively little expense by the suction of the air required for the force-pump through sulphuric acid, and a close wooden box containing lumps of chalk. This method is well known in connection with other applications.

The blast of air may be hot or cold, and may be delivered in any manner adapted to increase and effect more intimate contact between the air and the liquid containing the ammonia.

By adopting what I call the atmospheric or blowing principle, nearly the whole of the ammonia can be liberated from the solution in which it is contained, without any fire or external heat applied to or under the still or boiler, but, if the liquor be heated, the solubility of the alkaline gas is diminished and its extraction is facilitated.

Gas liquor is, in this country, the most common, and at the same time the most economical, source of ammonia, and the system of extraction by forcing air would, of course, be equally applicable to ammoniacal bone liquor, or to any other chemical preparation in which the caustic ammonia is held in solution.

The principles already indicated may, perhaps, be illustrated with advantage by a brief description of a working-plant actually constructed at Deptford for the purpose of extracting ammonia. An excavation has been made in which is sunk a reservoir for containing the gas liquor, and having the following dimensions:—namely, 35ft. long, 7ft. wide, and 6ft. deep. The bottom is formed of 1ft. of concrete, two courses of bricks, and of two courses of red flat tiles; the sides are of 14in. brick-work, two courses with tiles in conjunction with concrete.

The wrought-iron still is set in brick-work, so that flame may play more than half round its external surface. It is 30ft. long by 6ft. in diameter. About 4,000 gallons of gas liquor are pumped into it from the reservoir for the purpose of being operated upon.

Heat is applied by means of a fire underneath, but a coil of hot air or steam pipes placed in the interior of the still or boiler would be equally efficacious. Two cast-iron 3in. air-pipes, which are attached to the ammonia generator, extend along its whole length, and are situated one on either side, and nearly at the bottom. They are perforated with holes increasing in size as they extend from the inlet. Into these pipes, and from them into the gas liquor, is driven atmospheric air by means of a pair of cast-iron force-pumps. These are 20in. in diameter, 1ft. 8in. stroke, with rods and slings, wrought-iron connecting rod and crank, and a cast-iron beam 6ft. long. On the entry of the streams of air they are caught and agitated by the twelve iron fans of a stirer, making about 80 revolutions per minute.

The air, together with the lime and the various constituents of the gas liquor (viz., water, ammonia, carbonic dioxide, sulphuretted hydrogen, sulpho-cyanides, &c.) are thus brought continuously into intimate contact. The air loaded with the volatile alkali which has become eliminated from the solution passes upwards into the steam chest and through a branch pipe into the purifier or washer. This is a small wooden vessel of the capacity of 350 gallons, containing lime and being about one-third full of water. It has a tight head and a stout perforated elm false bottom, the holes being concentric and increasing in number and dimension as they radiate from the inlet, which is brought below the false bottom.

This purifying vessel is furnished with a small agitator having two blades one revolving above and the other below the false bottom. There are two trial or test taps at appropriate heights, to test for gas or for water, and there is also a pipe sealed at one end, rather less than half way from the bottom, for the purpose of leading away any excess of liquid that may accumulate owing to the condensation of aqueous vapour which may pass over with the volatile alkali. There is a long straight tube or safety pipe from the washer, and the bent pipe from the ammonia generator is also provided with a safety valve and a vacuum valve. In the washer the ammonia is deprived of any remaining hydrosulphuric acid or other impurity that may have escaped being fixed in the generator. About half a bushel of finely sifted slaked chalk lime is found to be a suitable charge for the washer, and when this becomes saturated or impure, it is renewed by means of a pipe and tap placed at the bottom of the vessel. The washer being a close vessel soon becomes full of air and gas, which are forced by the pressure through a pipe opening into the top and leading to a coil or worm placed in a cold water cistern, and terminating in a deep close vessel about one-third full of pure cold water, which has been condensed from the waste steam from the engine. A portion of the ammonia becomes absorbed by the water, but the residue, together with all the air after bubbling up through the liquid, is conducted by a bent pipe to nearly the bottom of a second similar receiver, and thence in the same way to a third, but which is opened at the top.

The air, having fulfilled its function, is now permitted to escape into the atmosphere, the whole of the ammonia having, however, been arrested.

This last receiver, instead of water, contains a strong solution of chloride of iron, which being denser and possessing a higher specific gravity than water, offers a greater pressure and resistance to the passage of the gas. The iron salt is, of course, decomposed, with formation of muriate of ammonia in solution, with deposition of a green mud containing sesquioxide of iron, which, after having been calcined, is found to constitute an excellent pigment for wrought iron or wood-work.

After the whole of the ammonia has been extracted from the gas liquor, the contents of the still are run off into a draining pit, from which the clear solution finds its way into the sewers, and the solid inodorous lime compounds may be carted away.

This draining pit is constructed of 1½in. deal boards together with sand and brick-work. It is 4ft. 9in. wide, 5ft. 4in. deep, and 10ft. long. There are fillets whereon to rest three perforated shelves or platforms. The bottom is formed of perforated deals with 6in. of sand, also with gravel, and cement. There are channels and small drain pipes leading into a large central earthenware pipe, and from thence into the sewer. The sharp sand, &c., under the perforated boards can be removed at will, and be replaced by fresh materials whenever required.

Care must be taken that the large pipe from the boiler to the washer be sufficiently high to guard against any back pressure. The vacuum valve opens and admits air when the fire of the still is withdrawn and the steam becomes condensed.

In order to ascertain the exact state of the contents of the boiler at any required height, and to avoid tapping the upper portion of the boiler at too many places, the following simple contrivance is adopted:—There is one tap at the lower end, to which is attached a short pipe inside the still working easily on an elbow. To this pipe is connected a copper wire having its outlet just above the the external surface of the boiler, and by which wire the short pipe may have its orifice presented at any required height, at which it is desired to ascertain the state of the contents of the vessel. For instance, supposing the fire to be withdrawn, and the agitators to be quiescent, if the end of the tube were pulled up by the wire and the tap opened, a clear liquid would issue, which could be tested in order to ascertain whether the whole of the ammoniacal gas had been removed. On the other hand, if the short tube were allowed to lay along the bottom of the still, the opened cock would allow the green sulphocalcareous mud to escape. It is stated in Dr. Miller's "Elements of Chemistry" that, at a temperature of 32°, water takes up about 1,050 times its volume of ammonia; at 59°, 727 times, and at 78°, 586 times its volume. Water saturated with ammonia at 60° contains more than one-third of its weight of the gas, increasing in bulk from 1·0 to 1·5, and becoming specifically lighter. Hence the receiver should be not more than one-third or one-half full of water to allow for the increase in bulk caused by the solution of the ammonia.

In July, 1867, valuable papers upon the utilisation of the waste products of the manufacture of coal gas were read before that important body, the British Association of Gas Managers, by two of our first authorities on this subject, Dr. Letheby and W. Esson, Esq. Dr. Letheby declares that it is manifestly of the greatest importance that the liquor should be sent away to the gas works as strong as possible; it ought, in fact, never to be under 6° Twaddle, or of less than 12 ounces strength, and with proper condensation and judicious washing there should be from 29 to 30 gallons of such liquor produced from every ton of coals. The price in London is 2s. per butt, 8-oz., with an increase of 4d. per oz. on every additional ounce of acid strength. Below 3° of Twaddle or 5 ounces of acid it does not pay for working, whereas at 10° or 11° of Twaddle it is a valuable product. Both Dr. Letheby and Mr. Esson emphatically insist upon the importance of the strength of the ammoniacal liquor. So rapidly does the commercial value augment, in relation to its concentration that, whereas a butt of 108 gallons of gas liquor is worth 4s., the same quantity of caustic ammonia of specific gravity 0·900 is worth from £15 to £20. A lower strength of gas liquor than 6-ounce has not hitherto been thought worth working, but one advantage in Braby's system of extraction and concentration consists in the fact that a high strength is not indispensable. Even 2 ounces would in practice yield a profit.

As an evidence of the importance of an increased supply of ammonia and of its large demand, it may be mentioned that a firm with which the writer is connected recently offered 4s. per butt of 6-ounce liquor, and yet was unable to obtain a supply, showing that the value has doubled in the short space of two years. Mr. Esson describes an economical arrangement for the extraction of ammonia from gas liquor with the assistance of steam and by an apparatus similar to a Coffey's still, but which is subject to the disadvantage that the noxious gas (sulphuretted hydrogen) is not simultaneously fixed or disposed of, and that at least 15 per cent of ammonia is left in the liquor, which has afterwards to undergo the supplementary process of distillation with lime. The present ordinary method of making liquor ammonia is, as far as I am acquainted, from sulphate or muriate of ammonia, which is itself obtained from gas water. By Braby's process, liquor ammonia may be obtained much more quickly and economically from gas-liquor direct.

There are many gas-works where ammoniacal salts are now manufactured; but it is suggested that, in new works, or at those where the gas-liquor is not at present utilised, it would be preferable, in the event of the adoption of the principle herein advocated, that the ammonia, after concentration, should be sent to the sulphuric or muriatic acid works, rather than that the acids should be sent to the gas-works. In metallurgy, it is found more advantageous to transport the calcined or partly-prepared ores to the coal districts for smelting, rather than to take the fuel to the mines.

Barges fitted with tanks ordinarily employed in the conveyance of gas-liquor contain from 3,000 to 8,000 gallons. A land journey of 12 miles with two horses for a load of 500 gallons in a tank-van now costs £1. By rail, the cost of freight is 1d. per ton per mile.

The advantages of the above-described system may be summed up as effecting a considerable economy in labour, time, and occupation of plant together with the facility of extracting the whole of the ammonia from the gas-liquor in a pure condition. A manufactory, previously consuming 10,000 gallons of gas-liquor per week, may now utilise 24,000 gallons, and at about half the expense of fuel of that formerly incurred.

The great interest of this subject in a chemical point of view, its high importance to the metallurgist and manufacturer, and the increasing value of ammonia to the farmer (with whom it is almost another name for fertility and abundance), must constitute my apology for having engaged so much valuable time in its consideration.

## MANCHESTER STEAM USERS' ASSOCIATION.

### CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, October 26th, 1869, Hugh Mason, Esq., Vice-President, Ashton-under-Lyne, in the chair, when Mr. L. E. Fletcher, Chief Engineer, presented his report, of which the following is an abstract:—

"During the past month 167 visits of inspection have been made, and 404 boilers examined, 274 externally, 7 internally, 6 in the flues, and 117 entirely, while in addition 4 new boilers have been tested by hydraulic pressure, and specially examined both as regards their construction and equipment of fittings. In the boilers examined 61 defects have been discovered, 3 of them being dangerous. Furnaces out of shape, 3; fractures, 6; blistered plates, 8; internal corrosion, 14—2 dangerous, external ditto, 6,—1 dangerous; internal grooving, 4; safety-valves out of order, 1; pressure gauges ditto, 1; boilers without glass water gauges, 6; without pressure gauges, 4; without feed back pressure valves, 8.

"Explosions.

"Five explosions have occurred during the past month, by which nine persons have been killed, and twelve others injured. These explosions occurred with such rapidity at the close of the month, that it was with difficulty they could be kept pace with, and full particulars obtained. In four cases, however, the scene of the catastrophe has been visited by officers of this Association, and particulars of all of them will be found below, with the exception of No. 41 explosion, detailed reference to which it is thought better to defer till next month, as I have been appointed by the coroner to make an examination, and report to him on the cause of the catastrophe, while the inquiry is not yet completed. With regard to this explosion, therefore, it need now only briefly be stated that it took place at about half-past eight on the morning of Tuesday, October 19th, to an internally-fired single-flued or Cornish boiler, employed at an ironfounder's, and that it resulted in the death of two persons, as well as injury to three others.

"Before giving the details of the above explosions, reference may be made to two others which occurred in previous months, but the particulars of which have not yet been given.

"Not one of the explosions which have taken place during the past month, or any referred to in this report, have occurred to boilers under the charge of this Association.

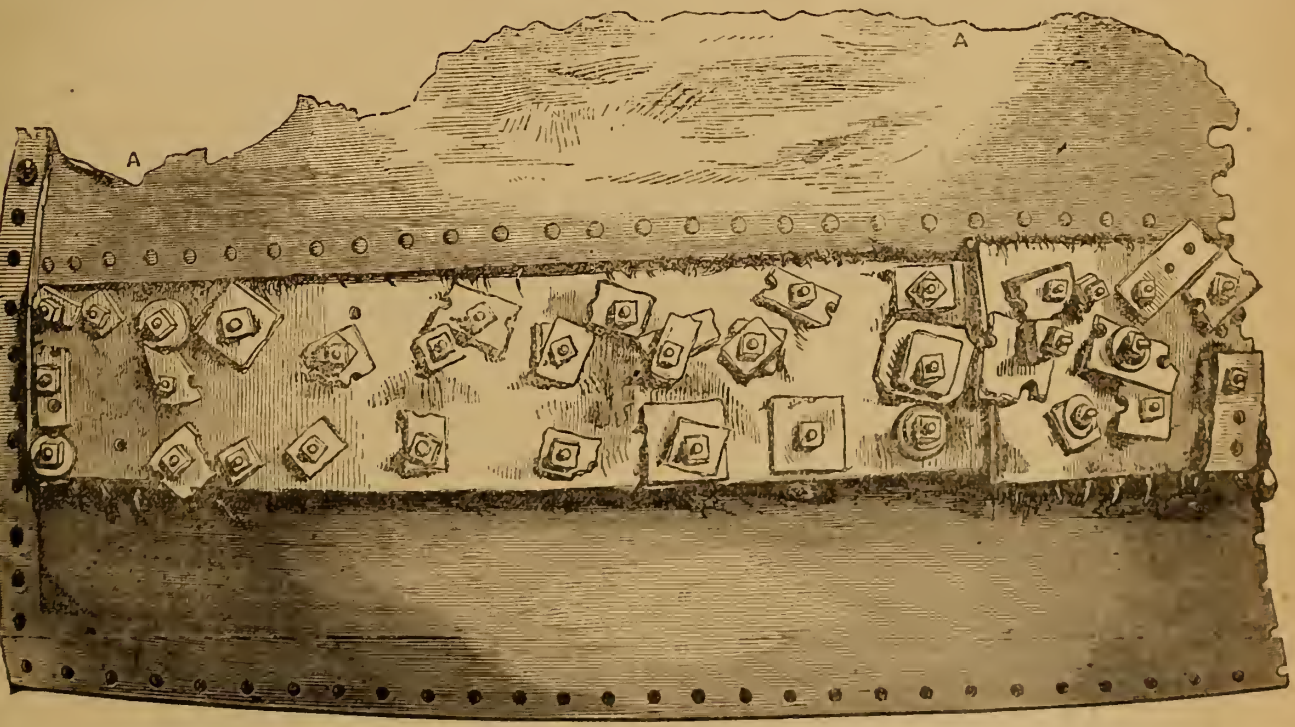
"Repairing Boilers with Bolted Patches.

"No. 28 explosion is an illustration of the grossly unskilful manner in which boilers are too frequently repaired. It occurred at a small steam forge at about ten o'clock on the morning of Friday, July 16th, and resulted in the death of one person, as well as in serious injury to four others.

"The boiler in question was of the plain cylindrical, egg-ended, externally-fired class, and measured about 21ft. in length by 4ft. 6in. in diameter, while the thickness of the plates was as nearly as may be $\frac{3}{8}$ths of an inch, and the ordinary working pressure about 50lb. on the square inch.

"It appears that about a year before the explosion, the attendant had discovered a flaw on one side of the boiler, which he repaired in the following unsatisfactory manner. Instead of having the defective part cut out and a new plate securely riveted to the the boiler, he laid a patch about 4ft. 8in. long by 9in. wide on the outside of the boiler over the defective part and in a horizontal direction, while he laid another patch of very similar dimensions inside the boiler immediately under the outer one, passing a number of bolts, amounting in all to thirty-seven, through the three thicknesses, and laying between each of the patches and the boiler plate, a layer, about half an inch thick, of hemp, or felt, or something very similar, in order to make the whole steam and water tight. To accommodate the length of the bolts to the three thicknesses of plate and two thicknesses of padding, forty-nine rough and irregularly shaped bits of iron were put under the nuts as washers, so that the whole presented the most unmechanical and clumsy appearance, looking far more like a relic from the scrap heap than a portion of a boiler worked at a pressure of 50lb on the square inch, and on the integrity of which the safety of life and limb depended. Such a patch, or rather plaster, proved, as might be expected, anything but effective. The boiler kept on leaking, and the water trickled down upon a longitudinal seam of rivets just below, eating the heads off on its way and also thinning the plate a few inches lower down, where it was covered by the brickwork forming the top of one of the side flues, until it was reduced for a length of upwards of 4ft, to the thickness of a sheet of paper, in consequence of which the boiler burst, simply from the loss of metal.

"No description, however, can do justice to this corroded plate and bolted patch. They must be seen to be realised. But I have appended a cut, which may give some little idea. The padding used for making the joint steam-tight may be seen in this cut oozing out at places from between the patch and the boiler, while there may also be seen at each side of this patch a long groove eaten into the boiler by the persistent leakage, the jagged line A A representing the primary horizontal rent where the plate was reduced to the thickness of a sheet of paper.



"It is scarcely necessary to point out that had this boiler been under inspection such a piece of patchwork, and such a dangerously-wasted plate, would have been at once condemned, and the explosion prevented.

"Weak Boiler Flues and Defective Fittings.

"No. 36 explosion occurred at an oil and seed crushing mill at a quarter before eight o'clock on the evening of Thursday, September 16th, and resulted in the death of one man, as well as in injury to one other. In laying the particulars of this explosion before the members of this Association, I cannot perhaps do better than give a copy of my report drawn up on the cause of the catastrophe at the request of the coroner, and which is as follows:—

"'The Steam Users' Association,
"'41, Corporation Street, Manchester, October 6th, 1869.

"'John Joseph Thorney, Esq., Coroner, Hull.

"'Sir,—In accordance with your communication of September 18th, addressed to Sir William Fairbairn, requesting him to come over to Hull, and investigate the cause of the explosion that occurred at . . . . . . . . . . . . , . . . . . . . . . . . . . . . on Thursday the 16th ult., or in the event of his not being able to do so, to appoint some one else to undertake the duty,—in accordance with these instructions I beg to inform you that I have examined the exploded boiler, as Sir William Fairbairn's state of health at the present time, I regret to say, quite prevents his leaving Manchester.

"'I visited the scene of the catastrophe on Wednesday the 22nd ult., when I found that the exploded boiler was what is termed a "Breeches" boiler. In this class of boiler, the two furnace tubes in which the fires are placed, run into a single flue at a short distance behind the fire-bridge, being united by a combustion chamber which tapers down from the width of the two furnaces to that of the single flue tube, and it is on account of this peculiar shape, the two tubes running into one, that the term "Breeches" boiler has been adopted. On measuring the boiler, I found that it was as nearly as may be 30ft. long and 7ft. in diameter, while the furnace tubes were 7ft. long by 3ft. in diameter, the combustion chamber 5ft. long by 3ft. 6in. high, and the flue tube 18ft. long by 3ft. 6in. in diameter, the general thickness of the plates being from three-eighths to seven-sixteenths of an inch, with the exception of the one at which the primary rent occurred, which was barely three-eighths of an inch. The boiler had but one safety-valve, which was enclosed in a box, and fitted with a lever. At the end of this lever there were two weights, one of which amounted to 26lb. and the other 30lb., while there was also a dead weight of 70lb. within the box, bearing directly on the valve, so that, as the lever had a proportion of 6 to 1, and as the diameter of the valve was 3⅝in., the pressure of steam at which the valve would begin to blow, provided it were in good working order, would be as nearly as may be 45lb. per square inch, though it would rise above that point if the steam were allowed to blow off strongly.

"'The boiler gave way in the flue tube, behind the furnaces and combustion chamber, the tube collapsing at the crown for a length of from 6 to 8ft. at about the middle of its length, and crumpling up as if made only of cardboard. The large opening formed by this rupture allowed the steam and hot water to rush out at each end of the boiler in a torrent, and it was this that caused the disastrous consequences already fully known to the jury. It was from this rush of steam and hot water that the furnace mountings were swept away, the fire-bars scattered like grape shot over the garden beyond the boiler-house, and some of the fragments thrown to as great a distance as 140 yards, while it was also from this cause that the poor fireman was blown over the adjoining building, and dashed against the roof of the coach-house.

"'With regard to the cause of the explosion:—The "Breeches" type of boiler is an antiquated one, and has long since been discarded. Its use has been attended with a series of most disastrous explosions, and with the very rarest exceptions it is now never adopted. It is important to call general attention to this fact, so that those steam users who still have boilers of this class in use should at once have them thoroughly examined, to see whether they are safe for the pressure at which they are worked. Added to the peculiarities of the "Breeches" type, the flue tube, though of so large a diameter as 3ft. 6in., was not strengthened as it should have been with encircling rings, flanged joints, or any other means; while it was not plated circumferentially as is the ordinary custom, but longitudinally, which does not give so much strength. Also the flat ends were stayed with diagonal rods, depending on a pin at each end, measuring an inch and an eighth in diameter; while the manhole was not guarded by any mouthpiece. In addition to this, there was no duplicate safety-valve, while the one provided was of very inferior and unreliable construction, so that it may be stated, without going into further particulars, that the boiler was decidedly second-rate in its construction, as well as in its fittings, and that it was not adapted for high-pressure work.

"While, however, the catastrophe might be attributed generally, and, at the same time correctly, to the second-rate construction and equipment of the boiler, it may be pointed out now that the explosion has occurred, and now that the flue tube has been crumpled up, and the fittings have been unseated, it is not easy to determine with certainty the final and exciting cause of the boiler's giving way, but, nevertheless, it may be desirable in conducting the present inquiry to go somewhat further into detail in this matter.

"'As already stated, the boiler failed from the collapse of the flue tube, and this it is clear could only have arisen from weakness of the tube, or excessive pressure of steam, or from the two combined. Sir William Fairbairn some years since instituted a series of experiments upon the power of flue tubes to resist external pressure without collapsing, and he found that the length of a flue tube is a most important element in its strength. Taking advantage of the result of his investigations, it appears that the flue tube under consideration, which was 18ft. in length, 3ft. 6in. in diameter, and may be taken as three-eighths of an inch in thickness, should not have collapsed at a pressure of 45lb., at which the safety-valve appears to have been loaded. This is on the assumption, however, that the tube was circular, or very nearly so, and that the plates were well put together. To ascertain whether this tube had been truly circular or not, I measured its diameter, vertically and horizontally at each end, and I found that there was only a variation of about half an inch. It does not follow, however, that the flue was circular throughout, and though true at the two ends it might have been out of shape at the middle, which is frequently found to be the case, while it was midway in its length that the crown failed. Added to this it must be remembered, as already stated, that the plates were not laid circumferentially but longitudinally, and it was close to the edge of the overlay of one of these longitudinal seams which ran along on the crown of the flue tube for a length of 6ft. that the primary rent occurred, when the top of the tube was driven down with so much violence as to cut its way completely through the bottom for a length of some 5 or 6ft. The character of the rupture is altogether peculiar, and very different to that which is found to take place in flue tubes plated circumferentially, and it certainly appears not to be by any means in favour of this mode of plating, though it is difficult to estimate the precise loss of strength. There are other sources of weakness to flue tubes than that of original construction. The plates may become over-heated, and thus weakened so as to be bulged down out of shape by the ordinary pressure of steam. The general appearance of this collapse, however, is by no means that of one which arose from overheating, whether from shortness of water or from any other cause, added to which, the top of the combustion chamber, which is as high as the top of the flue tube, is covered with scale, and so is the flue tube, with the exception of those parts where it has been cracked off by the bending of the plates consequent on the collapse, while, though the crowns of the furnaces are 3in. lower than that of the flue tube, it may be mentioned that they were perfectly sound throughout. It is possible, however, that the boiler may have been allowed to run short of water on some prior occasion, when the crown of the flue tube, though not then rent, may have been so weakened that it was only a matter of time when it would give way. Thus the flue tube may have been flattened by construction, by wear and tear, or by over-heating through shortness of water on some prior occasion, but the collapse has rendered it impossible to say positively whether such was the case or not. With regard to the question of excessive pressure of steam—the boiler, as it has already been pointed out, had only one safety valve, and that of a very unreliable character. It had evidently never been constructed for the service it had to perform. In the first place the lever was loaded with two weights, while a third was sometimes added, which is clearly an irregular mode of procedure. In addition to this, there was introduced within the valve box, and immediately on the valve, a weight of 70lb., while there was a space of only three-quarters or seven-eighths of an inch between the top of this weight and the cover, and the arrangement of the whole was such that nothing was easier than for the valve to be jammed fast, so that it was clearly one that should not have been used, more especially seeing that it was the only one fixed to the boiler. As, however, this valve had been removed from the boiler before I made my examination, I have no means of saying whether it was stuck fast or whether it was free at the moment of explosion. Possibly this may be determined in evidence.

"'While, however, there is some difficulty in determining precisely whether this explosion was due to excessive pressure of steam or to the weakness of the flue tube, there is no difficulty in determining how it might have been prevented, which is the most important issue of such an inquiry as the one now in hand, as this may lead to the prevention of similar catastrophes in the future. The experiments already referred to on the strength of furnace and flue tubes by Sir William Fairbairn, led to his strongly advocating that all such tubes should be strengthened with encircling hoops, while there is also a system of flanging the plates at the ring seams of rivets in these tubes, which has the same object in view. Both these modes of construction have for years past been very widely introduced, and are consequently well known. They have been found to be entirely successful, and are adopted in all first-class modern boilers. Had either one of them been employed in the present instance, the tube would have been amply secured against the danger of collapse. To have prevented the occurrence of excessive pressure of steam, the boiler should have been fitted with two efficient safety-valves, and it is a practice adopted by many of the members of the Manchester Steam Users' Association, and one that cannot be too generally adopted, to have one of these valves of external dead weight pendulous construction, which it is extremely difficult to overload or tamper with, and to have the other adapted for blowing-off either for high steam or low water, so that in case the water should at any time fall below the desired level, the valve would be raised and the pressure of steam allowed to escape, and thus the source of danger removed, and explosion rendered impossible. Hundreds and hundreds of safety-valves of the two descriptions just named are working satisfactorily, and they cannot be too generally adopted. Were they universally applied, many explosions would be prevented.

"'In conclusion:—Although there may be a difference of opinion as to whether this explosion resulted from weakness of the flue tube, or from overheating of the plates through shortness of water, or whether it resulted from excessive pressure of steam, there can be no question whatever, that had the flue tube been strengthened with flanged seams, encircling hoops, or any other equally efficient means, and had the boiler been fitted with two reliable safety-valves, one of them arranged for relieving the pressure of the steam as soon as the water fell below the proper level, that this catastrophe would not have happened, that the fireman would not have been killed, and that this inquiry would not have been necessary.

"'I remain, Sir,
"'Yours faithfully,
(Signed) "'Lavington E. Fletcher, Chief Engineer,'

"The jury, in returning their verdict, stated in a simple and direct way that 'the explosion was caused by the insufficiency of the boiler and of the fittings attached thereto' but that they did not 'consider such insufficiency was caused by 'malice aforethought,' or gross negligence of any person or persons whomsoever,' adding that they 'recommended to the owner of the boiler and others, the propriety of carrying out the suggestions made in the report just given. Thus they did not contradict themselves by calling such an occurrence 'accidental,' as is too often the case, but the verdict would have been clearer had the words 'or gross negligence' been omitted, and I am legally advised that they were not necessary to a correct form of verdict. The one adopted, however, is a great improvement on the ordinary one, which frequently states that 'the explosion under consideration might have been prevented,' and then finishes up by calling it 'accidental.' This abuse of the word 'accidental' has been productive of considerable misapprehension, and it is thought that the general use of the term 'no malice aforethought' instead would prove of much service. It was recommended by Sir William Fairbairn's Committee of Inquiry as to 'How far coroners' inquisitions are satisfactory tribunals for the investigation of boiler explosions, and how these tribunals may be improved,' a report on which subject was presented to the meeting of the British Association lately held at Exeter. This suggestion was adopted for the first time at the inquisition held in consequence of this explosion, and it was due to the coroner that this was done on that occasion. It is trusted that other coroners will follow his example in conducting similar inquiries.

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### Tabular Statement of Explosions,

From September 25th, 1869, to October 22nd, 1869, inclusive.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 37 | Sept. 26 | Plain Cylindrical, Egg-ended Externally fired | 1 | 1 | 2 |
| 38 | Oct. 6 | Double-flued, Furnace, Internally-fired | 2 | 6 | 8 |
| 39 | Oct. 14 | Plain Cylindrical, Egg-ended Externally fired | 2 | 1 | 3 |
| 40 | Oct. 18 | Plain Cylindrical, Egg-ende Externally fired | 2 | 1 | 3 |
| 41 | Oct. 19 | Single-flue, or Cornish, Internally fired | 2 | 3 | 5 |
| | | Total | 9 | 12 | 21 |

### "Working a Corroded Boiler a Few Days too Long.

"No. 37 explosion occurred at a colliery to a plain cylindrical, egg-ended, externally-fired boiler, at about half-past eleven o'clock on the morning of Sunday, Sept. 26th, and resulted in the death of one person, as well as in injury to one other.

"As this explosion took place at a considerable distance from Manchester, and as the explosions of these externally-fired colliery boilers are generally so very similar in their character, I did not think it worth while either to visit the the scene of the catastrophe personally, or to send an officer of the association to report me thereon, but from the evidence given at the inquest, as well as from information furnished me by those who have visited the spot, I have gathered the following particulars, which prove of interest:—

"The boiler, which, as already stated, was of the plain cylindrical, egg-ended, externally-fired class, was set in the middle of two others, one, if not both of which was of the same construction as itself, while it measured about 35 feet in length by 5 feet in diameter, and was worked at a pressure of about 35 or 40lb. on the square inch.

"This boiler gave way at the bottom of the shell over the fire, when it was ripped into two or three main portions and hurled from its seat, while one of the boilers alongside was also dislodged from its bed, and turned bottom upwards.

"It appears that the boiler was 20 years old, and that it had been re-bottomed about ten or eleven years ago, while the water with which it was fed was corrosive, in consequence of which the plates over the fire were materially reduced in thickness. A boiler-maker was therefore instructed about three months before the explosion to effect repairs, but found the plates so much worn that he recommended the manager to have a new boiler at once instead of repairing the old one. A new boiler was consequently made, and had been lying alongside for a month, ready to put in as soon as convenient opportunity offered. Owing, however, to some stoppage in another part of the works, the exploded boiler had been worked on a fortnight longer than it otherwise would have been, and hence the immediate occasion of the explosion.

"This explosion may prove a useful caution to those members of this association who will persist in working old boilers to the very last possible point, and thus causing great risk to themselves, as well as grievous anxiety to the association's chief engineer. While there is no danger of explosion if boilers are fairly kept up to a good state of repair and carefully worked, it is impossible, without great risk, to exact the last hour of work from a boiler before laying it on one side. Explosions, as in this instance, will not wait on the convenience of boiler owners, and it is not within the limits of human science to determine the precise point at which explosions will occur to an old and worn-out boiler. The only safe course is to lean a little to the side of prudence, and it is trusted that the lesson of this explosion will not be lost.

### "Opening the Blow-out Tap of Boiler in Work and Forgetting to Shut it.

"No. 38 explosion, which resulted in the loss of two lives and in injury to six others, occurred at about half-past eight o'clock on the morning of Wednesday, Oct. 6th, at a wire works.

"The boiler, which was one of seventeen, all connected by the steam pipes, was of double-flued horizontal construction, and similar to those of the Lancashire type, excepting that of having the fires placed inside the tubes; it was heated by the flames passing off from a couple of mill furnaces, one of which was connected by a brick flue to the left hand tube in the boiler, and the other to the right hand one. The length of the boiler as nearly as may be was 22 feet, its diameter of the shell 7 feet 6 inches, and in the furnace tubes 2 feet 6 inches, while the thickness of the plates was seven-sixteenths of an inch, and the working pressure about 45lb. The boiler had a single float to show the level of the water, but no glass water gauges.

"The boiler gave way in the left hand flue tube, the crown at the first ring seam of rivets bulging down and rending open for a width of 15 inches. On the occurrence of this rent, the steam and hot water rushed out in a torrent and principally at the front end, carrying away the brick flue connecting the left hand tube to the mill furnace, and playing with considerable violence into an adjoining building, in which a number of men and boys were working, in consequence of which eight of them were scalded, and two so severely that they died shortly after. The boiler, however, was not moved from its seat.

"The cause of the rupture in the boiler is unmistakable. The plates of the flue tube had been overheated through the shortness of water. It appears that the charge of regulating the water supply, as well as of blowing out the whole series of seventeen boilers, was entrusted to one man, and that it was his duty to open the mud or blow-out taps at the bottom of the boilers twice every day, and to lower the water level about 3 inches. And it further appears that he opened the mud tap of the boiler in question at the usual time on the morning of the explosion, but unfortunately forgot to shut it again, so that the crowns of the flue tubes were soon laid bare, the plates rendered red hot, the right one somewhat distorted, and the left bulged down and rent as already explained. The attendant does not by any means contradict this view of the matter, but says he supposes he must have left the tap open, though he does not know how he could have done so. He was considered as a very steady and reliable man, and, I am informed, is very much distressed at what has happened.

"At the inquest the jury concluded that the explosion was caused by the attendant's omitting to close the blow-out tap belonging to the boiler, but, on account of his good character, they were desirous of saving him from a charge of manslaughter. The coroner, however, declined to accept the verdict in any other form, and therefore a verdict of manslaughter was returned.

"While it is clearly an act of omission for any man to open a blow-out tap when the steam pressure in a boiler is fully up, and not carefully to close the tap again, yet as such oversights are occasionally found to occur, this being by no means a singular case, it is certainly advisable to adopt all such reasonable precautions in the equipment of boilers as will render all such such oversights, when they do occur, as harmless as possible. With this view it has been frequently recommended to the members of this association that they should blow out from the surface of the water, and have a scum tap fixed above the level of the furnace crowns for this purpose. Though this would not entirely do away with the necessity for opening and shutting the mud tap at the bottom of the boiler, it would very much diminish it, and it is clear that if the mud tap were left open, whether by oversight or malice, it would only lower the level of the water an inch or so, and then blow steam, leaving the water at the ordinary working level, and thus the furnace tubes covered. Attention also has been called again and again to the value of low water safety valves, which relieve the pressure of the steam as soon as the water falls below the proper level. With such valves the boilers in question were not fitted. It is true that as there were seventeen boilers connected together in this instance, one low water safety valve would scarcely have reduced the pressure on the whole series, though it is thought that a large valve blowing freely would have had a considerable effect, and, by allowing a large volume of steam to escape, would have given an alarm, and shown that something was wrong.

"It cannot escape the attention of those versed in the verdicts returned by coroner's juries on boiler explosions, how rarely any other verdict than that of 'accidental death' is returned, however badly the boiler may have been made, or however badly it may have been wasted, provided that the responsibility of the improper make and condition of the boiler rest on any one else than the attendant, but when, as in this case, the explosion is concluded to be due to the oversight of the attendant, a verdict of manslaughter is promptly returned, while no suggestions are given as to such precautionary measures as the owners might have adopted for the prevention of the disaster. Were the same justice dealt out to boiler makers and boiler owners as was dealt out to the poor boiler attendant in this instance, there would be few other verdicts in consequence of boiler explosions than that of 'manslaughter,' and were this the case, it is thought a material instance, there would be few other verdicts in consequence of boiler explosions check would be given to the recurrence of these fatal catastrophes.

### "The Danger of Plain Cylindrical, Externally-Fired Boilers.

"The association has for years laboured to call steam users' attention to the danger of external firing and to the treachery of the plain cylindrical colliery boiler, and the two following explosions, viz., No. 39 and 40, particulars of which are given below, and by which four persons were killed and two others injured, are illustrations of the correctness of this view.

"No. 39 explosion occurred at a colliery at about a quarter past twelve o'clock on the afternoon of Thursday, Oct. 14th, and resulted in the death of two men, as well as in injury to one other.

"The boiler was of the plain cylindrical, egg-ended, externally-fired class, with the plates laid longitudinally, so that the seams of rivets ran in line from one end of the boiler to the other. It was about 30 feet in length by 6 feet in diameter, while the thickness of the plates was three-eighths of an inch, and the pressure to which the safety-valves were loaded about 35lb. per square inch.

"The boiler gave way at the bottom over the fire, rending in a somewhat zig-zag course throughout its entire length from the front to the back, when the cylindrical portion of the shell opened out and tore away the two hemispherical ends, the parts being thrown to considerable distances, and the pipes and ruins of the seating scattered right and left. Added to this, a stonemason lighting his pipe at the fire door was killed on the spot, and two other workmen struck by the falling *debris* and seriously injured, one of them dying shortly after, while, in illustration of the force with which some of the fragments were thrown, it may be stated that a horse standing in a butcher's cart some thirty yards off was struck down and instantly killed, as by a cannon ball.

"With regard to the cause of the explosion, it was stated at the inquest that the boiler, though only a little more than three years old, had been under repair several times, and that two new plates had but just been put in over the fire, while it was as the steam was being got up for the first time after this that the explosion took place. The engineer stated that though the ordinary working pressure was about 35lb., yet that it could not have exceeded 24lb at the moment of explosion, while he was confident that the plates put into the boiler were of first-rate quality, so that 'it was a mystery to him why the boiler burst, as he considered it ought to have stood a pressure of 300lb. on the square inch.' The foreman smith said he was 'beat entirely in endeavouring to account for the explosion.' To this the coroner added that 'the Government Inspector of Mines had made an investigation, but admitted that he had no light to throw on the subject, and therefore it was apparent that the occurrence was shrouded in the greatest mystery.' The jury, without requiring further evidence, found that 'the deceased was killed bp a boiler explosion, but how the castastrophe originated there were no means of ascertaining.'

"In this case the inquest was conducted with considerable dispatch, being held the day but one after the catastrophe, so that it was concluded on the same day that the report of the occurrence reached Manchester. On the Association's Inspector reaching the scene of the disaster, he found that the boiler had been cut up and thrown on the scrap heap the day after the inquest was held, so that those who had charge of the boiler seemed resolved that if they could not arrive at the cause of the explosion themselves, nobody else should do so. The colliery engineer, who could have given the inspector some information as to the rents and flight of the parts, was most uncommunicative, and referred him to the scrap heap for information, and to the record of the inquest in the local newspaper, so that but few particulars could be obtained. After the association had gone to the expense of sending an officer between 100 and 200 miles, in order to throw light on the cause of a fatal steam boiler explosion, and thus to save human life, this reception was rather discouraging, though by no means singular.

"The facts of the case, however, speak for themselves. Here is a boiler but three years old, which has just been repaired and turned out as sound, yet, on the first time of getting up steam, and before the pressure had exceeded 24lb., it explodes, while all connected with it consider the occurrence as an impenetrable mystery. Such boilers certainly deserve the character this association has given them, viz., that of being untrustworthy and treacherous.

"No. 40 explosion occurred at an iron and steel works at about half-past seven on the evening of Monday, the 18th of October. The boiler, which was one of a series of five set side by side, and the second from the left hand, was of the plain cylindrical, egg-ended, externally fired class, set with a flash flue, and measuring 40 feet in length by 6 feet in diameter, while the thickness of the plates was seven-sixteenths of an inch, and the blowing-off pressure 50lb.

"The boiler gave way, as externally-fired boilers are prone to do, over the fire, dividing in two at the fourth ring seam of rivets near the firebridge, and also rending at a longitudinal seam running across three widths of plate at the bottom of the shell and at the front end, just where repairs had been at some previous time effected. On the occurrence of these rents the boiler was thrown from its seat, the front portion being hurled to a distance of about 150 yards to the right, while No. 1 boiler, on the left of the exploded one, and No. 3, on its right, were both dislodged. At the time of the explosion it appears that the fireman, as well as a man employed in wheeling ashes, and a young woman who had just brought up some tea for one of the workmen were standing near to the boiler, when the young woman was killed on the spot, both of the men severely scalded, the fireman having his leg broken, and being thrown into the canal, and altogether so seriously injured that he died shortly after.

"It appears that the boiler was about fifteen years old. and that it had been frequently repaired, the part over the fire presenting a very patched appearance, and having several cracks starting from the rivet holes, some running out to the edge of the plates, and others from hole to hole, while this boiler, like the one last reported on above, exploded the first time that it was set to work after repairs had been effected, the steam having been up but a quarter of an hour. Boilers that burst immediately after being repaired cannot be trustworthy.

"Conclusion.

"In drawing this report to a conclusion, it may be stated in brief that the seven explosions referred to herein, by which eleven persons were killed and seventeen injured, all resulted from the simplest causes, and might have been prevented by the exercise of 'common knowledge and common care.'

"L. E. FLETCHER,
"Chief Engineer."

Offices:—41, Corporation-street, Manchester.

## THE ROYAL SCOTTISH SOCIETY OF ARTS.

## ALTERED RELATIONS OF BRITISH AND FOREIGN INDUSTRIES AND MANUFACTURES.

By David Stevenson, F.R.S.E., President.

(Abstract.)

In the period that has elapsed since I last retired from this chair, not only have mighty strides been made in all departments of art and science, both at home and abroad, but events, political and social, have occurred in rapid succession, so that the whole national aspect of our country is materially altered; and in no respect, perhaps, is the change which a few years has brought about more apparent than in the altered relations which exist between our own and foreign countries in the all-important subject of arts and manufactures. This alteration, as you are aware, has been very generally regarded as favourable to foreigners and detrimental to ourselves, and has resulted in directing general attention to the subject of education, which is undeniably the question of the present day—the theme of our politicians—the study of the thoughtful class of practical men, to whose hands chiefly are confided the interests of the working classes of our country; and, I may add, the difficulty of all who have attempted legislation bearing on the social condition of the people.

I am emboldened, on the present occasion, to ask you to listen for a short time to some remarks regarding what appears to me to be the true international position of our arts and manufactures, and the causes which operate unfavourably to their full, or at least their advantageous development, and perhaps you will be all the more content to listen as the observations I have to offer are, I am well aware, not in accordance with the views which have been pretty widely expressed in this country.

These views, whatever may be the exact opinions of their supporters, seem to assume the form of two distinct propositions—First, That the manufacturing skill of the working classes of this country is on the decline; and, secondly, That this is due to the want of technical education. In short, a cry has been raised that all nations are beating us, and this cry at the time of the French Exhibition in 1867 almost assumed the character and proportions of a national panic, and resulted, as you are aware, in appointing Government Commissioners of inquiry, who took abundance of evidence and made elaborate reports—in sending deputations to ascertain the state of foreign education and manufactures—and in holding educational conferences in all parts of the kingdom.

Now, no one will deny that at the first great International Exhibition, inaugurated by the late Prince Albert in 1851, British manufactures held a pre-eminence, both as regards quality of workmanship and wide-spread monopoly, which subsequent international exhibitions have demonstrated, cannot now, at least in so many departments, be claimed for them; and on this admitted fact as a foundation, the whole of our national agitation on the subject of technical education has been reared. Nor does it appear that this national jealousy is peculiar to ourselves, for it may be stated, in passing, that the French in 1863 appointed a commission on technical instruction to examine the institutions of our own and other countries, in consequence of the Minister of Agriculture, Commerce, and Public Works in the French Cabinet having called attention to "the great progress made by other countries in arts and manufactures compared with that made by France," so that we have not been the first to raise the cry of the supposed national decline of manufacturing skill.

Now, to go back to the Exhibition of 1851, we then, as already stated, had confessedly great national pre-eminence accorded to us. But the system of transit by steam and railways brought to our shores, attracted by this the earliest of international exhibitions, the thinking classes of all parts of the world, who came to see and to judge for themselves, and who went away, I have no doubt, satisfied with the superiority of British workmen in most departments of manufacture, and since 1851 foreigners have undoubtedly made good use of their time. They have cultivated with success the branches of manufacture in which we excelled and they were deficient, and the result is just what might have been expected, being the natural consequence of intelligent manufacturers and skilful workmen applying their minds and hands to attain perfection in their own department of business, after seeing with their own eyes that superior work was done by their neighbours. This improvement in foreign manufactures seems a necessary result of international exhibitions, and yet we find some of the English jurors at the last French Exhibition, who were consulted by the Commission of Inquiry, evidently expressing surprise at this natural state of matters, and reporting that they are sorry to say that, although we may be still unsurpassed in many of our productions, we no longer hold that pre-eminence which was accorded to us in 1851. Now, it would, I think, be overstraining to an enormous extent, even the old-admitted British pre-eminence and the circumstances that may have led to it, to expect that such people as the French and the Americans are incapable of rising to equal excellence with ourselves.

Allow me, in explanation of these views, and in illustration of what I may term the imitative qualities of a people, to refer to certain facts within my own knowledge and observation. They happen to prove that British manufacturers can benefit by foreign example, and they will, I think, also show that progress in any scientific or practical department of trade in no way necessarily infers a falling off in the talent or the skill of the nations from whom the lesson of improvement has been derived. The facts to which I refer are instances in which our country has profited by the excellent example of foreigners, and, first, I notice steam navigation.

In visiting America in 1837, for the purpose of informing myself on the subject of American engineering, I was at once struck, as I think any engineer would have been, with the advanced state of steam navigation in the United States, and determined to investigate the subject with great care. Railways at that period were not at all in general use, and America, with its enormous rivers and lakes, was just the country where it might be expected that steam navigation would be carried to great perfection, and so it was. By adopting fine lines for the models of their vessels, and using engines of high power and long stroke, I found that their swift steamers easily attained a speed of over 16½ miles per hour. Now, at that time, I must remind you that British steamers were invariably built with bluff bows, being what is termed sea-going ships; that their engines were under deck, and had short strokes; and that the speed attained was, even in the best vessels, not much more than half of that regularly run by the Hudson and New River boats.

In 1838, when I published the result of my observations, giving the lines of two of the swiftest American steamers, I found that my professional brethren, and especially shipbuilders, were much disposed to distrust the accuracy of my statements as to the speed attained by American vessels. But my observations were correct, and the American pattern was not only very soon thereafter adopted by our shipbuilders, but was followed out with the success of which you are all aware. The American build of 1837 has been gradually adopted, and many steamers now navigate the Clyde at a speed of over 20 miles per hour, while the ocean packets belonging to the Cunard and Inman lines maintain a speed of 15 knots on the passage across the Atlantic.

I would refer to another instance within my own observation, where our manufacturers, finding the necessity of exertion and imitating the example of foreigners, have, within a comparatively short time, made rapid advances. I allude to the manufacture of dioptric lighthouse apparatus. About thirty years ago the manufacture of lenticular apparatus was exclusively Parisian, and the lighthouse of Inchkeith in Scotland, and the Start Point in England, were, in 1835, supplied with dioptric apparatus made in Paris under the direction of the late Mr. Alan Stevenson, engineer to the Commissioners of Northern Lighthouses. During the same year Mr. Stevenson interested Messrs. Cookson, of Newcastle, in the manufacture of lighthouse lenticular apparatus, and that firm produced in 1836, under Mr. Stevenson's directions, the apparatus for the Isle of May, being the earliest first-order apparatus made in this country. It was obvious that there was a field for such manufacture, and it was thereafter taken up by Messrs. Chance, of Birmingham, who now are successful competitors with the French; the apparatus constructed by them is found in all quarters of the world, and the firm of which I am a member has employed them to construct from our designs apparatus for lighthouses not only in this country, but in America, India, New Zealand, and Japan.

The two cases I have stated afford a proof of the undeniable fact that an intelligent nation, if a sufficient inducement presents itself, will profit by the example of other countries. But it does not follow that the introduction of improved steam vessels and the construction of dioptric apparatus in Britain necessarily imply a decline of steam navigation in America, or of lighthouse manufacture in France. The progress of other countries is, as I have attempted to show, the natural result of example, which in certain cases has been followed by our own country; and, let me add, that when in 1837 I found the steam navigation in America in so advanced a state, I found all the railways in the country laid with English-made rails and chairs, and English locomotives plying on some of their lines. But who for a moment would expect that the acute and far-seeing American people would up to the present time continue to take their rails and locomotives from England, when thirty years ago they had fairly outstripped us in their steam navigation? We have successfully followed them in that department, and the Americans, when I visited the country, were receiving their first lesson in railways; but, after receiving that lesson, they had no difficulty in assimilating their railway works to the climate of their country, the steepness of the mountains, and the circumstances of their trade, and constructing at Pittsburg and elsewhere the greater part of their own ironwork, and building all their own locomotives,—one of the results of their application of locomotives to steep gradients being the introduction of American engines into this country in 1840, for the Lickey incline of 1 in 37, on the Birmingham and Gloucester Railway.

But let us now consider, in so far as we have elements to enable us to do it, whether I am right in assuming that the changed relations between our own and foreign countries, do not indicate that we have declined, but that our competitors have improved in manufacturing skill, and for this purpose I shall appeal to a body of testimony, the trustworthiness and value of which cannot be called in question by any one who has carefully perused it. I refer to the reports of artisans selected by the Society of Arts to visit the Paris Exhibition of 1867, and to report the information obtained.

The first report in the series is that of the cabinet-maker, in which the following statements occur. "We find," he says, "that the foreigners prefer Birmingham and Sheffield steel, and we were shown tools from London which they considered superior to their own. As I remarked before, I consider them more proficient in shaped work, but in preparing, fitting, and finishing carcasses and inside work, drawers and dovetailing, we are decidedly superior. In that branch of cabinet-work to which I have been most accustomed, viz., book-cases, wardrobes, &c., it is admitted ours is more substantial, better put together, and finished cleaner—our dovetailing and drawer-work is much neater as a rule. In hanging draperies and curtains, I consider the French throw us completely in the shade."

The porcelain decorator, a branch in which we should have been prepared to find the English inferior, reports, "that our productions at this Exhibition are greatly in advance of all our former efforts; while in the general commercial articles of our trade, we are really ahead of them." Of five medals given to Minton's workmen for porcelain decoration, the jurors gave four to English, and one to a German workman; and of four medals given to Copeland's, three were given to English, and one to a German, and not one to a Frenchman at either place. "So much," adds the reporter, "for the charge of English inferiority or incapacity."

The reporter on saws and tools says, that "England is still in advance of France, Belgium, and Germany, for the highest excellence in the perfection of model and of a cutting edge in saws and tools;" and the cutler asserts, "that in all articles which require a keen-cutting edge, Sheffield stands at the head of all her competitors."

The glass painter states, that "for greater variety and graceful design in their arrangement of ornament, I think the French are superior to us, but for richness and a more pleasing harmony of colour, I think the English glass painters as a body are second to none."

In chairmaking and wood carving the English are reported on the whole to be deficient. A cabinet draughtsman says, "France is before us in design, but not in workmanship;" and adds, "the palm for workmanship must be given to Messrs. Jackson and Graham of London, whose exhibit is the finest in the entire Exhibition."

In ribbons and lace the foreigners surpass us, but the English articles of hosiery were reported not to be excelled by anything in the Exhibition.

In pottery, the reporter says, "after a minute examination of the various stalls, both home and foreign, I have come to the conclusion, and the fact is forced on my mind, that the British workman is not to be surpassed, if he can at all be equalled;" and the tilemaker states that "in reference to the productions of English and those of continental manufactures, after closely examining the various collections, I have little hesitation in stating that the continental productions are much below the standard in comparison to English manufactures in this branch of industry." England is reported to "stand foremost in the quality and design of works in terra-cotta; and for variety and excellence of earthenware, it maintains that superiority which has so long distinguished her."

The carpenters and joiners "consider Parisian joiner's-work to be far inferior to that done in this country." British joinery holds its place amongst the nations of the world. Of Belgian work, "they have little that is favourable to remark;" and America exhibits a class of work far more like the English in quality.

The stone mason claims for his own countrymen "more skill and system in executing their work, both as regards quality and quantity;" while the coach maker reports that the foreigners do not construct their work with such effectiveness and durability, and "sees nothing yet to tarnish the reputation of English coachbuilders."

An interesting report follows on shipbuilding, in which the author says, "I was very much surprised by the scarcity of work connected with that class, with the exception of that sent by England, which was very good and plentiful."

In silver-work it is stated, "we see at once that France and England occupy the first rank as producers of high-class art work in the precious metals, and of the two the superiority must be acknowledged to be on the side of France."

In hammered iron also, the only competitors of consequence are said to be French and English. The former excel in taste and effect, but they are not more skilful as smiths; the reporter adds, "in fact, I think the English excel" in that department. Another reporter on ornamental iron thinks "the English are far behind the French," but that these two countries are the only competitors. Three reports are given on watchmaking. In one it is stated that England "still maintains her superiority in substantiality of workmanship and system for accurate time keeping;" in another, the English watch and chronometer maker is said "still to stand at the head of his profession;" while the third, on clockmaking, states, that in this branch "the French surpass in every point."

In tailoring, it is the reporter's conviction "that the west-end tailor of London is by far the best, and greatly the quickest workman."

The reporter on bookbinding says, "the works exhibited by England, form as fine a collection as the nineteenth century has produced, and it is therefore no matter of surprise that the majority of medals for binding were awarded to the English." The worker in leather says, "nothing which I could take as a sample of national skill would, in my opinion, equal the production of the English manufacturers."

In worsted yarns and mixed textile fabrics, the French are reported by two different reporters to be superior, and of the machinery for manufacturing such fabrics, it is stated, "it is impossible to find any within the precincts of the exhibition, or elsewhere, to compare with the English." This same reporter further states, that every exertion is being made by foreigners to supersede us in these departments of trade.

Next come important reports from Mechanical Engineers, from which I quote the following extracts:—"For finish and sound workmanship, I saw nothing to surpass the British display. Amongst all the other nations, including the French, the machinery was of a heavy build, with much waste of metal, and evidence of want of skill in design. Before visiting Paris, I had heard much of French and Belgian locomotives, and their cheapness and superiority over ours, but I have not the slightest hesitation, after having carefully looked at all the specimens of this class of work which I could find in the French, Prussian, and Belgian courts of the exhibition, in saying that the best foreign locomotives were but bad copies of English originals."

Allow me very shortly to add to the testimony of the artisans whose words I have so fully quoted the result of my own observation on the French Exhibition of 1867.

Though present at the exhibition professionally, to report on a particular branch of engineering, I, in so far as time admitted, examined the mechanical engineering department, and I certainly came to the conclusion, that to a visitor, judging from what can be seen on an outward inspection, the locomotives and other engines from British exhibitors, as respects finish, held a very favourable place as compared with those of the other nations exhibiting. It is true that in large marine engines, and in large iron forgings, we were quite surpassed; and if size is to be taken as a criterion of perfection, we should certainly have nothing to say on behalf of our acquirements; but the country in which the exhibition is held has enormous advantages, particularly in the production of large machinery. At what sacrifice to the exhibitor could large marine engines and forgings, such as those exhibited by our foreign neighbours, have been transferred by us for exhibition in the Champs de Mars!

After observation on the spot, then, and careful study of all the evidence I could procure, I have no difficulty in concluding, First, That any alteration in British manufacturing pre-eminence and monopoly since 1851 is due not to decline of British workmanship, but to increased excellence of the work of foreign nations. Secondly, That in most departments of trade Britain still maintains pre-eminence in skill; and thirdly, That the departments where the foreigners excel in skill are those chiefly of art workmanship.

But now the question may fairly be asked, Is then the present system of education in this country, both in its character and extent, sufficient, and do we require to make an effort to maintain, if not to improve, our manufactures? Have we, in short, attained perfection? And to this question we have no hesitation in giving a negative reply. Improved education and increased exertion are every year more loudly called for. No one will venture to dispute, as indeed is fully borne out by the Artisans' Reports, that in all departments of art workmanship the foreigners—in the fine examples constantly presented to the workman's view, and in the thorough training afforded by their schools of design—show us an example worthy of our careful imitation. But while this may be fairly admitted, we cannot join in the sweeping cry that has been raised, that our workmen in all departments are losing their cunning, and that all this is due to the want of technical education.

Mr. Russell says, "The English are not an educated people. They are, at least, an ill-educated people. They educate themselves as best they may; the blind lead the blind. They have fallen behind their rival nations. They have been abandoned to their fate, and they suffer."* I can hardly conceive a more satisfactory refutation of this general condemnation than the highly creditable volume of artisans' reports, to which I have referred. A selection, I will venture to say, of more ably written documents, replete with more valuable information, could not be produced by the workmen of any nation in the world.

If, indeed, I held the views expressed by some writers as to the extent and kind of education necessary to prepare the workman for his duty, I should, perhaps, be driven to adopt those terms of wholesale complaint. For it has been asked, "Why should not the miner find compensatory pleasure for the darkness of the mine in a knowledge of the gases by which he is surrounded and of the minerals he is extracting?" "The intelligent ditcher," it has been said, "should so arrange his work before he puts a spade in the soil that every bit of earth is moved out of its old place into its new the shortest way over the least distance, with the least force." Now, I cannot help thinking that such views are, if not purely fanciful, at least very impracticable. All education which can tend to make a workman excel in his style of workmanship cannot be too highly commended, but it is obvious that all education does not tend to this. To take an example: it is clear that to the stone-mason, as such, it can be of no value that he should be able to tell whether the stone he is working be from the Coal-measures or the Old Red Sandstone, whether it be a granite or a syenite. But if he be employed in the finer or ornamenta departments of masonry, it is equally obvious that a knowledge of drawing and design may greatly tend to improve his style of workmanship, and facilitate its execution. And hence we may safely conclude that it cannot profit the mason's manipulation to study geology, whereas he may attain much benefit from attending a school of design.

It seems to me that in the desire to impart to the working-classes a general course of study, much harm may be done; for it must be kept in view that the possession of ten fingers, coupled with a large store, it may be, of head knowledge, does not necessarily give the power to any lad to become an accomplished workman. To excel in handicraft is a gift possessed in different degrees by different persons, just like excellence in classical or scientific accomplishments; and it is only, at best, by an early apprenticeship to the work, and a patient practice of it, that most persons, even though having what is called a mechanical turn, are enabled to acquire perfection; and it would be exceedingly undesirable to employ either the heads or the time of apprentices in studies which have not the direct effect of improving their manipulation and management of the materials with which they have to deal. The recent advocates of improved techinal education, in their zeal for head knowledge, have given to perfect manipulation greatly too subordinate a place; and in the educational arrangements they propose, they do not consider and provide for the time and difficulty of acquiring those high manipulative attainments which every skilled workman should aim to possess. Because, after all, let me ask, what is it but manipulative superiority that gives success to any branch of manufacture, and laborious practice, coupled with some amount of natural aptitude, will ever make a first-class workman?

What, then, ought to be the education of such a man? Clearly every branch that can help him to perfection in work, but as clearly nothing that will simply occupy his time without furthering the all important acquisition of manipulative skill.

Now, in attempting to define these limits, I think we may be assisted by keeping in view the following general propositions:—

First, That the elementary or primary education of the schoolboy cannot be too perfect, consistent with the boy's capacity, and the time that can warrantably be allowed to it; and this remark is of universal application, and ought to embrace all British subjects. Whether the primary education should be voluntary or compulsory, denominational or national, is not our object at present to inquire, and the ensuing session of Parliament is likely to decide.

Second, That a certain amount and kind of technical education would be invaluable for certain classes of workmen, especially those in the department of art work but this teaching, too, must not unwarrantably interfere with the time and practice requisite to enable the lad to acquire the manipulative part of his business, which is what makes the skilled workman; and therefore technical differs from primary education, inasmuch as it is not only not applicable to all, but, to be successfully carried out, much discrimination must be used in determining for what branches and to what extent it may be beneficially employed; and,

Third, That the acquisition of general knowledge, such as may be got by attending lectures, schools of arts, and otherwise, may safely be left to the taste and discretion of the workman, and must depend chiefly on the position to which he aspires; but as all cannot be foremen or managers, it is obvious that technical and general education, as I have defined them, cannot be regarded as of essential importance to the great bulk of the working-classes.

But it still remains for me to direct your attention to what has all along appeared to me as by far the most serious aspect of this important national question. Had the difficulty of dealing with the improvement and maintenance of our manufactures been only educational, it might have been effectually and satisfactorily overcome, even had our national deficiencies in this respect been so great, and additional schools and colleges so urgently required, as the most strenuous supporters of the educational movement represent. The country, I am sure, would not grudge any cost required to attain so desirable an object. But it seems to me that we have to deal with difficulties which mere money cannot overcome, and Government interference cannot wholly reach—difficulties, the mastery of which will, I venture to predict, ere long tax to the utmost the energy and the self-denial of the British nation. But what are these difficulties? Foreign countries have now, as we have seen, given their attention to manufactures; they have undeniably in their own people the minds and hands to do the work. Britain is freely thrown open to receive the products of their labour, and the simple question now is, who can produce good work at the cheapest cost? This is a view of the matter in which our foreign friends have great advantages, and to this, I believe, coupled with foreign restrictions on the introduction of our manufacture, we may chiefly trace the altered position which industrial Britain occupies among the nations of the world. The habits and dress of foreign workmen are in every way more simple than ours; their rate of pay is greatly lower, and they can turn out their work at a price with which the high wages of this country render it impossible for us to compete; and with us wages are still increasing. In my own experience, indeed, I am enabled to state that the wages now paid at Dhu Heartach Lighthouse works exceed by upwards of 30 per cent. those paid at the works at Skerryvore Lighthouse, which was executed thirty years ago in the same part of the country, and under precisely similar circumstances; and since then, it is proper to remark, the price of ordinary provisions has risen in nearly the same proportion.

Let me give an illustration out of many that may be cited of the practical working of this state of matters. An extensive shipbuilder in this country lately gave an offer for a contract, as he thought, at an almost unremuneratively low rate. The work was let to a foreign firm, and on visiting the country shortly afterwards he saw on the stocks the vessel for which he had offered, and he told me that, on inquiry, his loss of the contract was quickly solved, as he found that the wages paid to some of the skilled workmen in that foreign shipbuilding yard were less than one half of what he was paying at home! The Trinity House of London requiring dressed granite blocks for the Longships Lighthouse, accepted the lowest offer, being that of a firm in Dinan in Brittany; so that even in the very heart of our granite district of Cornwall the English workman is undersold in producing stones to build a lighthouse on the shores of his own country.

Now, these very grave considerations have led me to direct your attention this evening to our national manufactures; and in order to bring that subject before you in all its aspects and in all its importance, it was necessary that I should take exception to the opinion so widely expressed, that the skill of our workmen has declined; and on this point I trust you are satisfied from the evidence I have been able to lay before you; and it was further necessary that I should combat the idea that improved technical education would remove the whole of the difficulties under which our manfacturers are on all hands admitted to be suffering.

The cure, it seems to me, must rest chiefly and primarily with the working men themselves and their employers: and if between them they cannot devise some means whereby British work can be manufactured and sold at something like foreign prices, we must be content, I fear, to resign our national manufacturing pre-eminence, and meekly to succumb to the advantageous position of our foreign competitors—unless, indeed, foreign habits should alter, and foreign wages should increase in some such ratio as our own; but it would be neither wise nor politic to rest satisfied with an expectation, the realisation of which is at the best uncertain, and certainly very distant. But is there not still hope for us? Is it not the case that as yet there has been too little deliberative and friendly communication between the employers and the employed on this most urgent and important subject?

Instead of antagonism between employer and employed, let us rather see intelligent and thoughtful co-operation, if we desire that Britain should cope with its formidable rivals. The interests involved are momentous, and the combatants numerous and influential, represented on the one hand by the manufacturers and their capital, and on the other by the workmen and their trades unions. Both might be cordially united in one common effort to save our country's manufactures and promote their common good. We do not blame either party for protecting their rights by all lawful means, but so long as their exertions are antagenistic and hostile, commercial depression must continue; and the manufacturers will ultimately find, perhaps when it is too late, that their capital will be unremunerative, and the workmen that high wages and short hours will not restore diverted or declining trade.

## THE INSTITUTION OF CIVIL ENGINEERS.

At the first ordinary General Meeting of the session, held on Tuesday, the 9th ult., Mr. Charles Hutton Gregory, the President, made the following observations on taking the chair :—

Although every member of the Institution in this country has already received copies of the recent communications addressed to the Government of India, it is felt that the Institution ought not to meet for the first time after the vacation, without some reference to an attack on the honour of the profession, which has justly aroused, in India and in England, a deep feeling of indignation.

On the 18th of October, copies were received here of a notification gazetted by the Public Works Department of the Government of India, in which it was alleged that the Governor-General in Council was given to understand, that in the civil engineering profession in England, it was a recognised practice for civil engineers employed by public companies and otherwise, to receive, in addition to the salaries paid them by their employers, commission on contracts given out, or stores or materials ordered or inspected by them, and other like pecuniary considerations for services done, or intended to be done, which were considered legitimate sources of emolument.

The Council immediately met, and unanimously passed a series of resolutions, emphatically denying that such practices were recognised in the profession, and asserting that any engineer detected in such practices would be held to be guilty of disgraceful conduct, which would disqualify him from being a member of this Institution. Regret was expressed that so grave a charge should have been received and published by the Government of India without proper inquiry, as such inquiry would have shown that the charge was absolutely untrue; and, having reference to the grievous wrong which such an imputation, stamped with such authority, was calculated to do to an honourable profession, an appeal was made to the Government of India to cause the scandalous statement to be withdrawn.

This protest was transmitted to the Secretary of State for India, who only reached London on the 25th of October, but who, on the 27th, amidst the pressure of other public business, received a deputation from this Institution, comprising the President and every member of Council then in London. The deputation pointed out to His Grace not only the injustice which the notification had done to the whole profession, but also the serious effect which it would produce upon the public service in India, as such a disgraceful stigma, cast upon civil engineers as a body, would bring to a crisis the wide-spread discontent already existing among the civil officers of the Public Works Department; and they submitted that unless the notification were withdrawn, it might be expected that the Government of India, at the very moment of taking upon itself the construction of all the public works of that empire, would loose the services of the best of those, whose experience would, at such a time, be essential.

The Duke of Argyll promised to investigate the case, and, with the natural instinct of a just and high-minded statesman, has put on record that "he regards with implicit confidence the indignant repudiation by the Institution of any recognition of the practice referred to in the notification."

By the mail of October the 29th, the Council forwarded their protest to the Governor-General of India, and sent copies of the correspondence to the many engineers who had addressed them and claimed their intervention.

Time will probably throw more light upon the causes and motives of this most ill-advised notification.

If in the engineering profession, as in others, there may be instances of secret dishonesty, such acts are not recognised as legitimate. The profession has not sought to parade its purity before the world, but the members of this Institution know how carefully anyone believed to be unworthy of it has been excluded from this the representative body of the profession; and although happily such instances are rare, and such practices are from their nature most difficult of detection, yet steps have before now been taken, which have issued in some persons charged with misconduct ceasing to belong to the Institution.

At the approaching annual general meeting the Council will ask that ratification of their action which they are confident that the members will unanimously and cordially give; and if among the public there be some cynical minds which, while very sensitive for their own repute, can take pleasure in a libel directed against others, the members of this Institution may feel sure that, in vindicating the honour of the profession, they will have the sympathy of all honourable men.

## SUBJECTS FOR PREMIUMS.

### Session 1869-70.

The Council of the Institution of Civil Engineers invite communications on the subjects comprised in the following list, as well as upon others; such as 1st. Authentic details of the progress of any work in civil engineering, as far as absolutely executed (Smeaton's account of the Eddystone Lighthouse may be taken as an example); 2nd. Description of engines and machines of various kinds; or 3rd. Practical essays on subjects connected with engineering, as, for instance, metallurgy. For approved original communications, the Council will be prepared to award the premiums arising out of special funds devoted for the purpose.

1. On steam and hydraulic cranes, and on the application of steam power in the execution of public works.
2. On the different systems and the results of the use of road traction engines.
3. On the theory and details of construction of metal and timber arches.
4. On land-slips, with the best means of preventing, or arresting them, with examples.
5. On the principles to be observed in laying-out lines of railway through mountainous countries, with examples of their application in the Alps, the Pyrenees, the Indian Ghâts, the Rocky Mountains of America, and similar cases.
6. On the working expenses of railways.
7. On railway ferries, or the transmission of railway trains entire across rivers, estuaries, &c.
8. On the systems of fixed signals at present in use on railways.
9. Description of a modern locomotive engine, designed with a view to cheapness of construction, durability, and facility of repair.
10. On the cost of maintenance of railway locomotives.
11. Description of continuous brakes which have been extensively employed on railways, and the general results.
12. On the most suitable materials for, and the best mode of formation of, the surfaces of the streets of large towns.
13. On the construction of catch-water reservoirs in mountain districts, for the supply of towns, for irrigation, or for manufacturing purposes.
14. Accounts of existing waterworks; including the sources of supply, a description of the different modes of collecting and filtering water, the distribution to the consumer, and the general practical results.
15. On pumping machinery for raising water, both for high and low lifts.
16. On the principles applicable to the drainage of towns, and the disposal of the sewage.
17. On the employment of steam power in agriculture.
18. On the ventilation and warming of public buildings.
19. On the design and construction of gasworks, with a view to the manufacture of gas of high illuminating power; and on the most economical system of distribution of gas, and the best modes of illumination in streets and buildings.
20. Description of successfully applied gas engines.
21. Critical observations on tides, and particularly as affecting coasts, estuaries, rivers, docks, and navigation.
22. On the maintenance, by sluicing, of the harbours on the coasts of France, Belgium, and Holland.
23. Description of the sea works at the mouths of the River Maas, and the effects produced thereby.
24. On the construction of tidal, or other dams, in a constant or variable depth of water; and on the use of wrought iron in their construction.
25. On the arrangement and construction of floating landing stages, for passenger and other traffic, with existing examples.
26. On the different systems of swing, lifting, and other opening bridges, with existing examples.
27. On the measure of resistance to bodies passing through fluids at different velocities, and of fluids passing through pipes and in channels.
28. On the results of the best modern practice in ocean steam navigation, having regard particularly to economy of working expenses, by superheating, surface condensing, great expansion, high pressure, &c., and on the "life" and cost of maintenance of merchant steam ships.
29. On the practical employment of heated air as a motive power.
30. On ships of war, with regard to their armour, ordnance, mode of propulsion, and machinery.
31. On the measures to be adopted for protecting iron ships from corrosion.
32. On coal mining in deep workings.
33. On colliery explosions, and on the influence of different modes of "getting" coal on the safety of mines.
34. On the present systems of smelting iron ores; of the conversion of cast iron into the malleable state and into steel, and of the manufacture of iron and steel generally, comprising the distribution and arrangement of iron and steel works.
35. On the machinery for rolling heavy rails, shafts, and bars of large sectional area, and for forging heavy masses of metal.
36. On steel, and its present position as regards production and application.
37. On the safe working strength of cast and malleable iron and steel, including the results of experiments on the elastic limit of long bars of iron, and on the rate of decay by rusting, &c., and under sudden and prolonged strains.
38. On machinery for washing lead ores.

39. On the present state of submarine telegraphy, and on the transmission of electric signals through submarine cables.

The Council will be glad to receive, for the purpose of forming an "appendix" to the minutes of the proceedings, the details and results of any experiments or observations, on subjects connected with engineering science or practice.

The Council will not consider themselves bound to award any premium, should the communication not be of adequate merit, but they will award more than one premium, should there be several communications on the same subject deserving this mark of distinction. It is to be understood that, in awarding the premiums, no distinction will be made, whether the communication has been received from a member, or an associate of the Institute, or from any other person, whether a native or a foreigner.

The communications must be forwarded, on or before the 1st of February, 1870, to the house of the Institution, No. 25, Great George-street, Westminster, S.W., where copies of this paper, and any further information, may be obtained.

Charles Manby, Honorary Secretary.
James Forrest, Secretary.

The Institution of Civil Engineers,
25, Great George-street, Westminster, S.W.
Oct. 1869.

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## MR. ELLACOTT'S DESCRIPTION OF THE LOW WATER BASIN AT BIRKENHEAD.

The discussion upon this paper, which had been adjourned from last session, was resumed and concluded.

In the course of the discussion it was remarked that the Low Water Basin should be of the utmost value to the commerce of Mersey, inasmuch as the bottom of the basin was 12 feet under low water of spring tides, while the sill of the Princes Dock, at Liverpool, was 2 feet 10 inches above such low water. The works, however, as actually carried out, differed materially from the plans proposed by Mr. Rendel, as would be seen from the following figures:—

| | Mr. Rendel. | Actual. |
|---|---|---|
| Area of Basin ... ... ... | 37 acres ... | 14 acres. |
| Sectional area at entrance to river, at low water ... ... ... | 4,200 sq. ft. ... | 3,600 sq. ft. |
| Aperture of Sluices ... ... ... | 1,280 " ... | 826 " |
| Ratios of areas of Sluices to area of Basin at entrance, at low water ... | 1 to 2·3 ... | 1 to 4·33 |

From this it would appear that, in order to produce a given flow from the basin into the Mersey at low water, the velocities through the sluices must, by the actual plan, be 1·85 time as great as those intended by Mr. Rendel; and, if the action of a stream of water were as the square of the velocity, the destructive effect would be about 3½ times greater. It was further observed that the discharge from two sets of sluices, separated by an interval of 120 feet, differed essentially from the continuous sheet advocated by Mr. Rendel; and the result of such differences would lead to eddies and foul currents. Again, although the levels of the sills of the sluices were about the same as in the original designs, yet in place of the water having a short run through the sluicing chambers, the inner ends of the bottoms of these passages were at a level of 8 feet below the Old Dock Sill, and distant on an average, 265 feet from the paddles, the sills of which had been placed at a level of 18 feet below the Old Dock Sill, thus creating a fall outwardly of 10 feet, and from the sills of the paddles to the extremity of the apron another fall of 3 feet, making together 13 feet from the inlet side of the sluicing passages to the bottom of the Low Water Basin. It was argued that such a fall must have a tendency to tear up the bottom at the extremity of the apron. It was also pointed out that the use made of the sluices, as recorded in the paper, was entirely at variance with the use proposed by Mr. Rendel, who had repeatedly and distinctly stated, that the sluicing was only to remove the material brought in by the tides, say about one-tenth of an inch of newly deposited silt every twenty-four hours. Now, it was stated in the paper that the actual sluicing operations had been directed to the removal of a depth of 32 inches of clay, and the quantity displaced on fifty-six occasions was estimated at 106,100 cubic yards, which was equal to about 1 inch over the whole surface of the basin, or ten times the amount originally contemplated. Further, the velocity of efflux was never intended to exceed 5·08 feet per second, whereas on the 18th, 19th, and 20th of August, 1864, it was calculated that the velocity of discharge had been 30·87 feet per second, while if the whole of the fifty-six days were taken, it would be found that the average velocity of discharge was 26·54 feet per second. It was not stated to what height the sluices were drawn, but it was presumed that they must have been opened to their full extent. In making trial of such an important work, it would have been judicious to draw the sluices about 18 inches, or a little more, at one time, opening some of them, keeping others closed, and interspersing the apertures in such a way as to cause the current to act in the most efficient manner throughout the Low Water Basin. If this had been done it was believed that a current of 2 miles per hour would have sufficed to clear the basin of all ordinary deposits.

On the other hand, it was contended that in 1856, the parliamentary plan of Mr. Hartley abolished the Low Water Basin, and substituted in its place an outer dock, with locks, and a small entrance basin recessed back 400 feet from the Mersey; but the Low Water Basin was subsequently forced upon the Liverpool Corporation by the railway interests. The original idea in treating Wallasey Pool was that it should form a great highway leading to docks to be ultimately found on its margin. In 1858, however, an alteration was made, and Wallasey Pool was no longer regarded as a highway, but as a great dock. Obviously, then, what would apply in the one case would not apply in the other. It was asserted that the mode of sluicing suggested was inapplicable, as far as the working of the dock was concerned, and that it would have failed to keep the Low Water Basin open. It was maintained that there was no volume of water available to produce the requisite current, and therefore that the Liverpool authorities had acted wisely in determining to abandon the project, and at once to make a dock, with a small tidal basin, so far recessed from the Mersey, that it could be kept open by sluicing from the gates above.

It was stated that throughout the controversy in 1844, it was distinctly urged that it was not intended that the water should have an inclined downward action, but that it should issue from the sluices horizontally. It was alleged that the sluicing had failed, from the water having been projected downwards, which, so projected, followed the same law as a solid mass; it was reflected upwards, and produced an upper current. It might be quite true that in 1853 it was difficult to get water to maintain the Low Water Basin; but the conditions were very different in 1844 and in 1853. It was proposed, in 1844, that the Float should be filled at every tide to the level of the tide of the day; and inasmuch as the indraft from the Mersey would have been at the rate of half a mile per hour during the six hours of flood tide, the water would only carry material due to that velocity. But the rate of discharge was to have been 2½ miles per hour—a velocity amply sufficient to remove particles brought in by the flood.

In seeking for the cause of the failure of the sluicing operations, it was contended that the first thing to be regarded was the work to be done, and then the means provided for doing it. The primary object was to set in motion the body of water contained in the Low Water Basin. This was 1,750 feet in length, and varied from 300 feet to 400 feet in width; and the depth when the sluicing was commenced was 19 feet 4 inches. The weight of the water to be set in motion, or simply to be started, was 338,275 tons; and for this purpose twenty sluices were provided, having a combined area of 826 square feet, with a head of water against them at the first sluicing trial of 14 feet 3 inches, producing a total pressure of 336 tons, or less than the one-thousandth part of the load. This was a greater disproportion than was found to exist in other instances where a load had to be moved with a comparatively small power. Some intermediate gearing was wanted between the power and the weight; but in the work as carried out this had not been supplied. The 336 tons of power seemed to have been employed against the 338,275 tons of load at a velocity of about 17 knots per hour; that had simply had the effect of disturbing portions of the water, and throwing the water into a state of great confusion. Gradually the water appeared to have attained a more uniform motion, but at the end it resembled a series of eddies and strong currents rather than a stream.

With regard to the question of sluicing in water of considerable depth, it was observed that Mr. Rendel had evidently contemplated the removal of the deposit, not by the direct sluicing and violent action of the water rushing out of the Great Float, but by setting in motion, gradually and at a much lower velocity, the large body of water which had been previously collected, or which remained, in the Low Water Basin. The silt in the Mersey was of a very binding quality, and when it had once aggregated it was difficult to move it, except by great violence. There were sand-banks in the Mersey which resisted a velocity of from 8 feet to 12 feet per second; and therefore it was that Mr. Rendel had proposed very frequent sluicing, so as to prevent any serious amount of deposit and of aggregation taking place. Upon the general question of sluicing, it was remarked that if it were intended to effect scour by setting a large quantity of deep water, or at least a substratum of water, in rapid motion, it would be utterly impossible. No doubt, in the immediate proximity of the aperture of emission, the water would issue and would flow for some distance with a velocity due to the head of water with which it was propelled—in the case under consideration from the interior of the Great Float. But there were causes which prevented that action continuing to any considerable distance. In the first place there was the enormous friction between the moving water and the immovable bottom over which it flowed. Besides that, a volume of water moving with a high velocity through a body of water in a nearly quiescent state encountered a large resistance. When the endeavour was made to sluice the bottom of the Great Float at the Birkenhead Docks, the water rose up, spread out until it assumed almost an umbrella shape, and moved the deposit away for a short distance; then, as the water lost its velocity, the deposit again collected in banks, and the sand accumulated and aggregated, while a succession of waves was produced in the Basin. It was admitted that, under ordinary circumstances, it was possible to effect sluicing provided a sufficient quantity of water was obtained to give that general velocity, not bottom velocity merely, necessary to move the particular material to be dealt with; but it was impossible to establish a bottom velocity of great amount for any considerable distance. The opposite was indeed the case,—that the velocity of the water at the bottom was always less than the velocity at the top, except in the immediate neighbourhood of the sluicing operations.

## APPARATUS FOR WEDGING FACING-POINTS.

After the meeting Mr. Harrison (V.P. Inst. C.E.) explained a model and two drawings, illustrating plans which had been successfully tried on the North Eastern Railway, with a view to provide the means of preventing accidents at facing-points. These accidents had arisen from various causes. In some well-established cases, a blow from a wagon or carriage on the heel of the switch rail, had sprung the point sufficiently to throw a carriage off the line. A piece of coke or stone getting behind the points, which would stop them from entirely closing, might not prevent the lever worked by the signalman from apparantly coming home, without any defect being detected, owing to a certain amount of elasticity in the lever. Signalmen were frequently in the habit of putting up the danger signal before a train had quite passed, and, with the jerk, sometimes disturbing the facing-points. When the Queen's train passed over the North Eastern Railway, it was the invariable practice to wedge up all the facing-points on the line; and it was believed a similar plan was adopted on the Brighton and South Eastern Railways before express trains passed. This had led him to the adoption of the present plan. The first idea was to employ a separate lever to work the wedges, distinct from the points. This had been in use at the Pensher Junction for some months. It was afterwards thought that the turning of the points and the wedging might be done by one motion of the lever. This was accomplished by giving a double action to the wedges; but the segment movement, as shown by the model, was in practice the best, and had been in use for some time at Gateshead, on the Team Valley Line. Experiments had been made by putting an obstacle between the points and the rail; but in this case the wedges could not be forced home, the danger signal could not be lowered, and intimation was at once given that something was wrong. The slide motion for moving the points was worthy attention, independent of the wedges, as no slight or even considerable motion of the lever could move the points, and practically this motion in itself wedged them up. The cost was rather under £15 per junction, and the same handle was used which before worked the points.

In carring out these arrangements, Mr. Harrison stated that he had been assisted in all the practical details by Mr. Simpkin, who had the charge of this department on the North Eastern Railway; and he was so satisfied with the additional safety to be obtained by this plan, that it was to be at once adopted at all facing points on the main line of the North Eastern system, and in some cases facing-points would be introduced, where heretofore all trains had been back-shunted to avoid them. In all cases this arrangement was used in conjunction with a locking apparatus for the signals, &c.

## SWITCHES FOR RAILWAY JUNCTIONS.

Mr. R. Price Williams (M. Inst. C.E.) also exhibited and explained a new arrangement of switches for railway junctions. The main object of these switches was to do away with facing-points and their attendant evils, and to enable a train when passing through a junction to pass over a continuous and fished main line, or a continuous and fished line leading to the branch, according as circumstances may require. The switches were formed of lengths of rail, of the same section as the rails used at other parts of the road, with fishes at both extremities, at one end the bed-plate admitting a slight play, while at the other they were capable of being moved laterally, on the removal of the fish-plates. Each length, of what might be termed the main line switch rail, was firmly attached to the corresponding length of branch line switch rail, so that the two mutually supported each other, thus giving the necessary lateral stability. At the ends of the switch rails, capable of being moved laterally, sliding double fishes were employed. These moved on the fixed rails, and were so formed that when moved forward they held the switch rails firmly between their jaws, and thus ensured that the switch and the fixed rails were maintained fairly in line with each other.

# INSTITUTION OF MECHANICAL ENGINEERS.

## THE LE CHATELIER BRAKE.

By Mr. William C. Siemens, London.

In ordinary locomotive engines, when the valve gear is reversed while running forwards, for obtaining, in an emergency, the retarding effect of the full boiler pressure opposing the motion of the pistons, the reversed working cannot be continued longer than a few minutes without serious injury, owing to the heating of the cylinders and the cutting of the rubbing surfaces from want of lubrication; the cylinders act as pumps in the reversed working, drawing in the heated gases from the smoke-box and forcing them into the boiler. The object of the present plan is to enable locomotives, in taking trains down inclines, to be worked continuously for any length of time with the valve gear reversed, so as to obtain the advantage of the counter-pressure steam as a retarding power, instead of the train brakes, without involving the objections hitherto preventing the the use of continuous reversed working. In the regular working of locomotives, not reversed, the piston in its forward stroke is propelled by the full pressure of steam from the boiler, until the steam is cut off by the slide valve, after which the propelling power is continued through the remainder of the stroke by the steam expanding in the cylinder. But in the reversed working the distribution of steam is effected by the slide valve in the inverse order and on the opposite side of the piston, while the motion of the piston and driving wheels still continues in the same direction as previously; in the first portion of the stroke, therefore, the cylinder is open to the exhaust on the front side of the piston, but in the latter portion the steam, at full boiler pressure, is admitted, and opposes the forward motion of the piston. In the return stroke the front of the piston, in ordinary working, is in communication with the exhaust until nearly the end of the stroke; but in the reversed working it is to the back of the piston that the exhaust is open, and the piston accordingly draws in the heated gases from the smoke-box at atmospheric pressure, and in the next forward stroke the contents of the cylinder are compressed as soon as the exhaust port closes, and forced by the piston into the boiler against the full pressure of steam. The latter portion of each stroke of the piston is thus made against the full boiler pressure, which resists the motion of the piston, and consequently acts as a powerful retarding force to check the rotation of the wheels in the direction of running.

The simple and efficient plan designed and carried out by M. Le Chatelier for counter-pressure working consists in introducing a small jet of hot water from the boiler into the base of the blast-pipe of the exhaust port of the cylinder; this jet being discharged at boiler pressure into the atmospheric pressure of the exhaust passages, the greater portion of the water instantly flashes into steam at atmospheric pressure, and instead of the heated gases from the smoke-box, a moist vapour or fog is now drawn into the cylinder behind the piston. The rubbing surfaces are thus maintained constantly lubricated by the present of saturated steam, and all heating or cutting is entirely prevented. The jet of water is regulated so as to be always slightly in excess of the precise quantity required, the object being to prevent the possibility of drawing in any of the heated gases from the smoke-box; and the constant escape of a slight cloud of steam from the chimney affords an indication to the driver of the sufficiency of the jet. Mixed jets of hot water and steam in various proportions have also been employed in particular cases of working. The use of the counter-pressure working has the important advantage of rendering the great weight of the engine available as brake power; and as the amount of retarding power obtained from the counter-pressure steam against the pistons when running reversed is less than the propelling power of the steam in ordinary working, the engine wheels are not skidded upon the rails; but a steady retarding force is continuously applied to them within the limit of their adhesion. The wear of rails and tyres that is caused by the friction of the train wheels when skidded by the ordinary brakes, and the consequent injury to the wheels by wearing flat places in their circumference, are avoided to the extent that the counter-pressure steam is used as a brake on the engine; and the practical working of the counter-pressure plan has been found so satisfactory that its use has even been carried so far in many cases as to supersede the employment of the train brakes, not only in descending inclines but also in stopping and shunting at stations. In shunting, the steam regulator is left constantly open, and the motion of the engine is controlled entirely by the reversing handle. The employment of the counter-pressure working has now been extensively adopted in France, Spain, and other countries, as many as fourteen hundred locomotives being regularly worked on this plan on the Paris and Lyons Railway alone, both in descending inclines and in stopping and shunting at stations; and in all cases its adoption has been attended with complete success.

## WELL-SINKING MACHINERY.

By Mr. William Mather, Manchester.

In the operation of excavating boreholes for wells and other purposes, the principle adopted and carried out by the writer for all depths of boring has been the use of a rope for working the boring tool in the hole; and this principle obviates the serious expense and delay attending the plan of using rods for working the tool, when great depths of boring have to be executed. In the plan described in the paper the boring tool is worked by a flat hemp rope, which is wound round the drum of a winding engine, and on quitting the drum passes over a large pulley carried in a fork at the top of the piston rod of a vertical single-acting steam cylinder. The boring tool having been lowered by the winding drum to the bottom of the borehole, the rope is clamped secure at that length: steam is then admitted underneath the piston of the vertical cylinder, and the tool is lifted by the ascent of the piston rod and pulley; and on arriving at the top of the stroke the exhaust valve is opened for the steam to escape, allowing the piston rod and carrying pulley to fall freely with the boring tool, which falls with its full weight to the bottom of the borehole. A cushion of steam prevents the piston from striking the bottom of the cylinder, and the steam and exhaust valves are worked by tappets on a plug rod; a rapid succession of blows is thus given by the boring tool on the bottom of the borehole. The boring tool is composed of a number of chisels or cutters, fixed in the cast-iron head at the bottom of the long wrought-iron boring bar, which is guided vertically in the borehole by a couple of collars; and it is made to rotate a little between each blow, so as to strike in a fresh place each time, by means of a simple self-acting arrangement. The lifting shackle at the top of the boring bar is allowed to slide up and down through a short distance on the neck of the boring bar between two fixed collars; the upper face of the lower collar is formed with ratchet-teeth, and the under face of the top collar is formed with similar ratchet-teeth, but set half a turn in advance of the teeth on the lower collar. The intervening boss of the lifting shackle is also formed with corresponding ratchet-teeth on both its upper and lower faces, these teeth being in a line with one another. When the boring tool falls and strikes the blow, the lifting shackle, which during the lifting has been engaged with the ratchet-teeth of the top collar, falls upon those of the bottom collar, and thereby receives a twist backwards through the space of half a tooth; and on commencing to lift again, the shackle rising up against the ratchet-teeth of the top collar receives a further twist backwards through half a tooth. The flat rope is thus twisted backwards to the extent of one tooth of the ratchet, and during the lifting of the tool it untwists itself again, thereby rotating the boring tool forwards through that extent of twist between each successive blow of the tool; and this turning is found to be quite certain and continuous in action during the working of the tool. When a sufficient quanity of material has been broken up at the bottom of the borehole by the blows of the tool, the working of the percussion cylinder and pulley is stopped, the rope unclamped, and the boring tool wound up with great rapidity by the winding drum. A shell pump is then lowered down the borehole by the rope consisting of a long cylindrical shell or barrel, with a clack valve at the bottom opening inwards, and a bucket containing flap valves opening upwards. The rope is attached to the bucket, and when the pump reaches the bottom the bucket is worked up and down by the rope several times, so as to draw in the broken material through the bottom clack; after which the pump is drawn up again with the material contained in it, and the boring tool again lowered into the hole for continuing the boring. In the event of accidents from breakages or from any of the implements sticking fast in the borehole in rising, grappling tools, with hooked claws of suitable shape, are employed for laying hold of the obstacle and raising it; or if it cannot be brought up by this means, a solid wrought-iron breaking bar of very great weight is lowered into the hole, and allowed to fall upon the obstacle from a sufficient height to break it up into fragments which are then raised either by grappling tools or by the shell pump.

Numerous boreholes have been executed by this plan of boring, both in this country and abroad, for the purpose of obtaining water, and also as trial boreholes for ascertaining the nature of the strata in searching for coal or other minerals, the depth of the borings extending to as much as 1,300ft. The tubing employed, where the borehole is required to be lined, is of cast-iron, and is fitted together with turned joints, made with a wrought-iron covering ring, which is let into the thickness of the cast-iron and secured by countersunk screws, so as to make the joints perfectly flush both outside and inside. The tubes are forced down the borehole, either by screw-jacks or by hydraulic presses, without interfering with the operation of boring, which is carried on simultaneously within the tube. For raising a water supply by pumping from a borehole, the arrangement employed consists in suspending a pump barrel by pipes of the same diameter from the top of the borehole, with two pump buckets working in the barrel, one above the other; the rod of the top bucket is hollow, and is suspended from the horizontal arm of a bell-crank lever at the surface, and the rod of the bottom bucket passing up through the hollow rod of the top bucket is suspended from the horizontal arm of a second reversed bell-crank lever facing the first lever. The two levers being coupled by their vertical arms and worked by an engine, the two buckets move always in opposite directions; the top bucket in rising lifts the water above it while the bottom bucket is descending, and in the return stroke the bottom bucket ascending delivers the water through the top descending bucket. Although a continuous delivery of water is thus obtained of equal amount in each stroke, a serious shock is occasioned at the beginning of the stroke, in consequence of both buckets stopping and starting simultaneously, causing the whole column of water to be stopped and put into motion again at each stroke; and, as an air-vessel for keeping up the motion of the water is inapplicable, a modification of the two bell-crank levers has been arranged, which completely answers the purpose. The two levers are centered one above the other, the upper one being inverted; and the vertical arms are slotted, and are both driven by the same crank-pin working in the slots; in the revolution of the crank the dead point of one of the levers is thus passed before that of the other is reached, so that the first bucket is started into motion again at the end of its stroke before the second comes to rest. By this means the water is maintained continuously in motion with entire freedom from concussion.

## SOCIETY OF ARTS.

The 116th session of the society commenced on Wednesday evening, at the rooms, John-street, Adelphi, when Lord Henry G. Lennox, M.P., chairman of the council, delivered the opening address.

His Lordship, having expressed the great diffidence which he felt in again appearing as the chairman of the council, said that he would endeavour to shadow forth such a programme on questions of national interest, and affecting the commercial, industrial, and social welfare of the community at large, as should induce the members to feel an increased interest in a society which had for 116 years been endeavouring to promote the progress and improvement of arts, manufactures, and commerce. He noted with regret the deaths, since the society's last meeting, of three very distinguished members—namely, Dr. Roget, Professor Graham (Master of the Mint), and Sir Wentworth Dilke—and then passed on to notice the labours of the Food Committee, which had collected a mass of information on articles of food. The supply of meat, fish, poultry, milk, and grain, together with the distribution of them, whether by markets or otherwise, had occupied the attention of the committee. This information had been widely circulated, and had drawn attention to the solution of several problems. At the present time, he continued, the great problem for which solution is wanted is some means by which meat can be brought to this country, where it is dear, from our colonies and other countries, where it is abundant and cheap, in a raw state, unsalted and uncured. The committee had had before them many processes for arresting decay and decomposition; but hitherto the results have not been such as to warrant them in pronouncing any one as successful, although, in some instances, a sufficient amount of promise had appeared to justify the parties in further prosecuting their labours. Up to this point his lordship believed that the plan which appeared to hold out best prospect of success was that which presented the least novelty of conception, namely, the preservation of meat by means of ice; but it was evident that, unless ice could be produced much cheaper than at present, no appreciable results could be expected from this system; and, therefore, he was obliged to repeat what he said last year, that as yet an increased supply of meat to the people of this country appeared to depend upon the success which might attend the labours of our scientific chemists in producing artificial ice at an economical rate. To show the value of the Food Committee, his lordship said that Earl Granville had forwarded to them several packages of meat which had been received from the colonies, in order that the quality might be tested as food for the army and navy. The society had had under its consideration the best means for bringing about an improvement in the condition of British India, by developing the vast agricultural resources of that empire. The committee appointed last session to inquire into the whole subject of the hidden wealth of India had proved a great success. Papers had been read on the following subjects:—On the cultivation of tea, of silk, and of cotton; on Indian fibres; on waste lands; on hill settlements and sanatoria; and generally upon the state of trade with Central Asia and Thibet. Conferences had been held, and one result had been that the Duke of Argyle had promised to write to Lord Mayo in favour of extending the system of assisted exhibitions of agricultural produce in India. A discussion on tea culture had elicited some very interesting facts, one of the most important being that the quality of the tea grown in India is fully equal to that produced in China. A large quantity of land is still at the disposal of the Government suitable for tea cultivation. It was sad to read the figures as to the yearly growth and exportation of tea from the two empires, India and China. Taking our own consumption as the standard for Russia, America, and China, it would appear that in China alone there is an annual production of 80 or 100 millions of pounds, and only seven millions of pounds in India, and this after nearly a quarter of a century of cultivation. The society had offered a silver medal for the best treatise on the profitable production of tea. The culture of silk, rice, cotton, and other agricultural produce of India had received every attention. The conservation of forests in India, as opposed to the indiscriminate destruction of timber, will engage the attention of the society. The latter not only diminished the rainfall and promoted drought, but, by depriving the inhabitants of wood fuel, it led to the burning of animal manure for that purpose; thus the crops were deprived of a fertilising material, and evils flowed from the abuse of natural resources. It was to this waste of manure that some attributed the inferior crops of cotton in many parts of India, where the yield was only 70lbs. per acre, as compared with 400lbs. in the United States. The subject of trade with Central Asia would be again taken into consideration this session; and had it not been for the fog, Niaz Mahomed, a native of Yarkand, would have been present. His lordship next referred to the contemplated appointment of a mechanical committee, to be composed of professional men and amateurs interested in the various mechanical questions of the day, and by whom subjects relating to progress in mechanical invention would be discussed. The patent laws would continue to receive the anxious attention of the council, and a paper by Sir Joseph Whitworth would be read. He thought that our present patent laws very often acted unfairly, and in many instances operated as a serious impediment to trade. The society still directed its attention to art workmanship prizes and the system of examinations in connection with its union of institutions. The most distinguished candidate of the year was Mr. W. J. Wilson, of the classes held at the Polytechnic Institution, and to him a prize (first given by the Prince Consort) of 25 guineas was to be awarded.

## PATENT LAW.

### The Bovill Litigation.

*(Continued from page* 248.)

Mr. Bovill promptly followed up his success against Mr. Crate and the Manchester Association, by commencing suits against the different members of that association, and by bringing on for hearing in the Rolls Court the case of Bovill *v.* Cowan, the Chairman of the London Association of Millers. In the latter suit Lord Romilly delivered the following judgment, on the 30th July, 1867:—

Lord Romilly: I have read these papers, and I am of opinion that the only question there was for me to consider in the case was, whether there had been an infringement of the patent; I am of opinion that it is exactly the patent of the plaintiff; whether the plaintiff's patent is new or not is a matter which I have sent for trial in another case, but this is, in my opinion, so far as the exhaust is concerned, precisely and exactly the patent of the plaintiff. It is also, in my opinion, to be observed, this, like many other of the cases that have come before me, is a case in which the mill has been built with the express purposes of trying to get the invention of the plaintiff, with as much departure from his plan as is consistent with obtaining the advantages which his suggests. Now, with respect to the exhaust, it appears to me this is precisely what the patent of the plaintiff is. The patent of the plaintiff is to exhaust the plenum to such an extent, and no more, as will take away all the hot air from the mill stone case with the stive without touching the meal, for the purpose of utilising that stive. Now that, in my opinion, as far as I have gone, was never done before, I am quite clear that Cabanes' patent does not do it according to the description here given. It is a perfectly distinct thing, and that is literally and precisely what the defendant does upon the present occasion. Then, he says, if that be so, because, in fact, in the greater part of his argument, though he admitted that the only thing I had to determine was, whether there had been an infringement or not, and that the question of novelty was only before me, so far as it touched upon the question of infringement, yet he contends this, that in point of fact the stive room is not the stive room of the plaintiff, for that he does not utilise the stive by means of straining the air through a porous fabric. Now that is true, but I am of opinion it is settled by the cases before me, and in the Common Law Courts, which I followed, particularly the judgment in Bovill *v.* Keyworth, that the patent of the plaintiff is a patent for a combination, it is not merely that he exhausts the plenum, because, as he very justly says, that was exhausted before, but it was never exhausted in that particular manner, that is say, so regulated as merely to draw off exactly the stive, and not to disturb the meal, combined with and for the purpose of utilising that stive afterwards. Now that was never done before, and that he does, and this exhaust is precisely that.

Then, as I stated, in Bovill *v.* Keyworth it is determined that the patent of the plaintiff is a patent for a combination. It is a patent for a combination that I have exactly at this moment described. Well, the defendant's is exactly that by his combination he exhausts the air for the purpose of utilising the stive, but in order to avoid, if possible, incurring the liability which would flow from violating or infringing the plaintiff's patent, he utilises the stive without any porous fabric, but by means of long tubes and chambers in which the stive is deposited, or principally deposited, before it reaches the external air. That is unquestionably not the stive chamber of the plaintiff, but it is in combination with the exhaust exactly for the same purpose, and he does not use that because it is obvious that, if be took the whole of the plaintiff's patent precisely and exactly as it was, he could not have any species of *locus standi* in court for the purpose of defending it, and therefore obtaining all the essential parts of the plaintiff's patent, he makes an inferior stive chamber in order if possible to avoid the consequences of that. I do not think it necessary to go into all the details of the evidence on the subject, having gone into the matter so frequently before, and, having had the question so recently before me, I am of opinion that the plaintiff's patent is infringed by the defendants, and I am of opinion he is entitled to an injunction, and I will not grant any issue at all on the subject. If in the other cases it should turn out that there is no novelty in Mr. Bovill's patent, then the defendant will have the advantage of that. If, on the contrary, it should be so established, then I am not going to add to the litigation in this case by directing any fresh issue."

This judgment throws great light upon the powers of that branch of the Court of Chancery to do justice when Mr. Bovill's patent is under examination. The case had been previously before the Court on more than one occasion. Mr. Bovill had been cross-examined upon an affidavit he had made, and he was asked a question relative to a French patent of M. Cahaues', but he refused to answer any question founded upon that patent. The Master of the Rolls, however, decided that he was bound to answer the questions. Some of his answers are worth transcribing:—

"I look at the drawing of Cahanes' patent. I have read the specification some time ago. The drawing represents a fan blowing into a closed eye of a mill-stone, and so as to force air at higher than atmospheric pressure between the grinding surfaces of the stones. It shows a pipe from an exhausting machine introduced to the mill-stone case so as to draw off the air forced by the blowing fan through the grinding surfaces of the stones, but it does not exhaust the plenum. The drawing certainly does not exhibit the operation of exhausting the plenum of air which has been forced through the stones. It fails to do so. The description in the specification shows that. The apparatus exhibited in the drawing would not, when working, be an exhaust of the plenum. It is applied so that it cannot do it. It is applied so that it can draw away the warm dusty air forced through the stones—blown through between the stones. The air has no other way of escape. The drawing does exhibit that which is described in these words,—'I introduce a pipe to the mill-stone case from a fan or other exhausting machine, so as to carry off all the warm dusty air blown through between the stones to a chamber;' but it does not follow that the apparatus could be worked to do so. As shown and described the apparatus could not do it. As shown and described it could not suck away the plenum of dusty air forced through the stones. I say that all the elements for accomplishing the results of my patent of 1849 are not exhibited in that drawing of Cabaues' patent. The whole arrangement, as described by Cahanes' patent is quite different. In my patent the letter-press describes it and not the drawing. Referring to my patent, I in the first place do not exhibit the fans at all. My patent of 1849 describes that the exhaust of the plenum only is to take place. The drawing of Cabanes' patent is constructed so that that cannot be done. There are no appliances or apparatus or implements described in my patent of 1849. I have said that the apparatus, as shown in the drawing of Cabanes' patent, could not suck away the plenum of dusty air forced through the stones. I say that Cabanes' patent, as described in the specification, could not do it. You may put in force all that it describes. It describes some implements, and it describes the working of them, but whether that will effect it or not is another thing. It does not depend upon how they are worked. As shown and described in the specification, I say that it could not do it. As shown upon the drawing it would not necessarily carry off all the warm dusty air blown through between the stones. It is not apt machinery for that purpose. The apparatus there shown would not suck away the plenum of dusty air forced through between the stones."

We are unable to suggest any process of thought by which Lord Romilly arrived at the conclusions represented by his decision. We have looked through the evidence in vain for a trace of even so much evidence as a casual statement of Mr. Bovill himself, to the effect that his specification would enable a workman to practise his invention. We have seen that the jury in Bovill *v.* Keyworth were not asked any question on that point. The notes of that trial were referred to before Lord Romilly. Mr. Bovill's evidence, which we have quoted, is to the effect that if you [illegible] the apparatus prescribed by him, it does not follow you can exhaust the plenum, nay, that that apparatus will not do it. And we entirely agree with him! We believe that no man ever desired or attempted to exhaust the plenum in the sense the Court of Chancery put upon the expression. Lord Romilly's judgment in Bovill *v.* Goodier, deals with the word "plenum" as if it were technical for "mill stone case," and his Lordship seemed to harbour that opinion, when he said the plaintiff "very justly says the plenum has been exhausted before." His idea of a combination to support a patent it somewhat new. Vice-Chancellor Wood doubted whether the patent was for a combination at all. Lord Romilly holds that it had been established the patent was for a combination. The Court of Queen's Bench had certainly held that the invention lay in combining the blast and the exhaust, so as to increase the quantity and improve the quality of the meal. Lord Romilly held the invention to consist not in merely exhausting the plenum (which *per se* had been done before), but in doing it to a particular degree, combined with the subsequent utilization of the stive; so that a combination is not necessarily a combination of apparatus for producing an improvement in manufacture of any sort, but may be a combination, or rather succession, of processes, through which the subject of manufacture masses; thus, to use a washing machine for linen may be a patentable combination if you follow it it up by applying the soapy water to sanitary or agricultural purposes!

## COAL NAPHTHA AND BENZOLE COMPARED WITH PETROLEUM AND ITS PRODUCTS.

By Professor Van Der Weyde, M.D.

Benzole, which has lately been introduced as a gas carbonizer, was originally obtained from the benzoic acid found in gum benzoles, hence the name. Later it was found to be produced in great abundance by the distillation of coal tar. This tar, being distilled, gives a black oil called *dead oil*, which, by re-distillation, produces coal naphtha. This coal naphtha contains about seven per cent. of pure benzole, which it is quite difficult and laborious to obtain pure, for which reason most so-called benzoles are only coal naphtha, consisting of a mixture of several hydro carbon oils, having some solids in solution, but all possessing a similar degree of volatility. These substances are, besides the benzole, toluol, cymol, cumol, then a few solids in solution, called napthalin, anthracen, and finally phenylic and chrysolic alcohol. The latter substances are, however, perhaps rather a product of subsequent treatment than an educt.

The pure benzole is a hydro carbon, like the petroleum products, but of different chemical combination, containing, by weight, 12 parts of carbon to one of hydrogen, while the petroleum products contain only about five parts of carbon to one of hydrogen. Being richest in carbon, it has more power to increase the luminosity of gas than the same amount of petroleum naphtha; in fact, common air passed through it becomes combustible, and burns, according to Gmelin, with a smoky flame.

Notwithstanding this equal volatility, it is much heavier than petroleum naphtha, its specific gravity being 0·85 for water = 100; this corresponds with 35° of Beaume's hydrometer. Any petroleum product of this specific gravity is not volatile enough to make its vapour combustible at the common temperature, and even at 180° Fahr.; and will not burn well in a lamp, being, therefore, only used for a lubricator. Some natural petroleum of Western Virginia and Ohio, of exactly this specific gravity, give, by distillation, no naphtha at all, and only little kerosene, and, therefore, are only used for lubricators. The so-called paraffin oil, obtained at the latter stages of the distillation of petroleum, when all the naphtha and kerosene has previously been driven off, is too greasy and thick to burn well; it is therefore kept separate, and sold as a lubricator; its specific gravity ranges from 30° to 35° Beaume, and is thus about equal to benzole.

Common kerosone of a specific gravity of 0·79, corresponding with 48° Beaume, it is not even volatile enough to be used as a carbonizer, and will not make air combustible when blown through it, and will not burn without a wick. Benzole, notwithstanding its greater specific gravity, is just as combustible as petroleum naphtha, or so-called benzine, and it cannot be handled with as much safety as ordinary kerosene oil. The boiling point of good kerosene oil is about 240° Fahr., while it gives off combustible vapors at 110° and above, not below. The boiling point of benzole is 177°, while it gives off combustible vapours at the common temperature, like benzine from petroleum.

It may be set down as a rule that any fluid which can communicate illuminating vapours to air or gas, at the common temperature, will give off combustible vapours, which, when mixed with air in the right proportion, may make an explosive mixture. In this respect benzole is equal to the petroleum naphtha, or benzine. However, as its boiling point is some 100° higher than the latter substance, it is less volatile, and comparatively safer, though not absolutely safe, nor as entirely free from explosive vapours as good ordinary kerosene oil.

The specific gravity of benzole vapour is 2·77, that of gasolin = 0·39 (air = 1·00); the latter vapour has more expansive tension, that is, will expand further, consequently will take fire from a greater distance. If we take three open vessels, one containing kerosene, the second benzole, the third gasolin, and approach a flame to each of them, the gasolin will take fire at a short distance, the benzole will take fire at a shorter distance, the kerosene will not take fire at all, even when plunging the fire in it—it cannot burn without a wick, except above 110°, (benzole will only refuse to ignite without a wick below 40°. gasolin will take fire without a wick at 20°, and even below, if of a high grade.) This is a simple practical test of the comparative safety of these three important substances, now so extensively introduced for illuminating purposes.

## THE GAS SUPPLY OF THE CITY.

Dr. Letheby, the chief gas examiner appointed by the Board of Trade, has recently presented to the Court of Common Council his quarterly report on the quality of the gas supplied to the City of London, from which it appears that the average illuminating power of the City of London Company's gas at Jewry-street, was 14·72 candles, and at the new station in Cannon-street 17·34 candles; while that of the Chartered Company was 14·95 candles at Jewry-street, 14·96 at Leadenhall-street, and 15·63 at Gray's-inn-lane; that of the Great Central Company being 14·88 at Jewry-street, and 16·51 at the new station at Friendly-place, Mile-end. The apparent increase of illuminating power at the new testing stations is wholly referable to the use of the new testing burner prescribed by the referee, which gives at least 16 per cent. more light with the same gas than the old burner, which has been hitherto used for testing the illuminating power of the gas at Jewry-street. Dr. Letheby refers in his report to the effect of improved burners on the apparent increase of the illuminating power of the gas supplied to the City during the last 18 years, and he states that if the value of the old burner, which was used from 1852 to 1863 be called 100, that of the Steatite burner, which was used from 1863 to 1869, is 111·1, and that of the burner which is now in use is 128·9. So that almost *pari passu* with the progress of improvement in the quality of the gas by legislation there has been a like improvement in the value of the instrument for determining it; and thus in reality there has been but little change in the quality of the gas supplied to the City for the last 18 years, notwithstanding that it has been nominally raised by successive Acts of Parliament from 12 wax candles in 1851 to 14 sperm candles in 1868. Taking the Great Central gas as a fair example of the quality of the gas supplied to the City during the time, it appears from the published reports of its illuminating power from 1852 to the present time that it has been of nearly one uniform quality; for, if measured by the old burner of 1852, its average illuminating power from 1852 to 1857 was 13·33 standard sperm candles; from 1857 to 1863 it was 12·44 candles; and from 1863 to 1869 it was 12·57 candles. In fact, the published returns show that the gas supplied to the City at the present time is almost identically the same as it was in 1852—the apparent increase in the results as they are now recorded being entirely owing to the use of the new burner, which makes the gas about 29 per cent. better than with the old burner. As regards the purity of the gas, Dr. Letheby reports that it has been always free from sulphuretted hydrogen, and that the amount of sulphur in the gas, other than the preceding, has averaged 19·75 grains per 100 cubic feet in the City of London Company's gas, 25·97 grains in the Chartered Gas, and 12·71 in the Great Central. It is apparent from these results that the amount of sulphur can be easily maintained at an average of 20 grains per 100 cubic feet, and it is exceedingly desirable that this destructive impurity should be kept to a minimum proportion. The other impurity, ammonia, has always been absent from the City Company's gas, but it has been frequently present in excessive quantities in the gas supplied by the Chartered Company; and it is very probable that when it has not been discovered in the last-named gas its absence has been dependent on the improper use of a wet meter between the main and the testing-room—a proceeding which could not have been sanctioned by the chief engineer, who is one of the referees under the Act.

## REVIEWS AND NOTICES OF NEW BOOKS.

We resume our notice of the recent publications of M. Eugéne La Croix.

*Guide pratique d'Agriculture génerale, par A. Gobin, Professeur de Zootechnie, ancien Directeur de Colonie agricole pénitentiare, Membre Correspondent de la Société d'Agriculture d'Orleans, &c.*

The author remarks that it has been a moot question for many years whether agriculture should be considered as a trade, an art, or a science, The researches that have been made of late years, and the study of meteorology, chemistry, and the applied sciences on the part of leading agriculturists, must in some measure tend to place it in the ranks of the second, if not of the third, designation. It has been the habit of the British people to consider themselves as *the* agricultural nation *par excellence*; but the work before us must convince the most sceptical that our French neighbours have a *knowledge* of the latest improvements in the cultivation of the soil, however backward they may be in the *application* of them.

Commencing with general considerations of climate and atmosphere, and the varying conditions of the latter, the different parts of France are compared with other regions of the world, as to the nature of the soil, and their adaptibility to the leading productions of the country, which seems to be divided into districts devoted to the cultivation of the vine, olives, maize, grain, and chestnuts, the latter of which forms no inconsiderable item of the food of the country.

Agricultural implements, to which a chapter is devoted, are next considered, but so briefly that it is evident our lively neighbours are far behind us in the application of machinery, however attentive they are to drainage, irrigation, and manures, both natural and chemical.

Although the work is, from the nature of it, adapted only for the use of French agriculturists, the English reader will, by a careful perusal, find much that will interest him, and indeed may even gain a little knowledge, which, to a suggestive mind, could be turned into practical account.

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*Guide pratique de l'Ouvrier Mécanicien, par M. A. Ortolan, Mécanicien en chef de la Flotte, avec la Colloboration de MM. Bonnefoy, Cochez, Dinée, Gebert, Guipont, Juhel, Mécaniciens de la Marine, ex-éleves des Ecoles d'arts et Métiers.*

This valuable and useful work is announced as a collection of facts intelligible to all who understand the first four rules of arithmetic. M. Ortolan states that it was with a philanthropic desire that he placed himself in communication with those of his *collaborateurs* whose names appear as joint authors, and proposed to them that they should undertake the different portions of which the work is composed. Circumstances caused him somewhat to modify his original plan, but he has endeavoured to preserve the distinctive characteristics of each, for the general benefit of the working community.

The first division of the work, which treats of arithmetic, ignores the first four rules, as being "within the knowledge of all the world," and he compels the reader at once to take what may be termed, in the language of the day, "a sensational header" into what must be, to many of the class *ouvrier mécanicien*, the mysteries of mathematical formulæ. Although the young student is apparently taken out of his depth, he will flounder about but a very little while ere his feet will touch the ground, as by easy gradation, the author leads his pupils on, and very soon reduces the formidable array of figures and signs into the most simple of elementary "sums." The form and value of the characters and signs used in the formulæ are familiarly set forth in tabular form, one perusal of which will go a long way in dispelling any idea of difficulty in the mind of the scholar whose abilities have been hitherto untaxed in this direction. Following this table, we find a number of formulæ worked out side by side by the ordinary arithmetical process, one glance at which gives a very fair idea of the great saving to be effected in abstruse calculations. So far only simple figures have been dealt with, now fractions—vulgar and decimal—are introduced, till we come to a most intricate mass of algebraic computations; but so gradully is it approached that every difficulty seems to disappear ere it is reached.

The succeeding chapters are devoted to Practical Geometry, of which we can only say that it is much after the style of most elementary works upon the same subject.

The second division of the work, which bears the name of M. Guipon, treats of Mechanics, a most interesting subject, than which none opens a larger field for the exercise of intelligence and ingenuity on the part of the student. Commencing by stating that the Science of Mechanics "treats of the action of force upon matter; it is divided into two parts, static and dynamic, the former constituting of the laws of equilbrium, and the latter the motion of bodies." After giving the proper definition and expounding the laws of time, movement, rest, weight and density of matter, composition of forces, centre of gravity, measure of force, &c., the author explains the different prime movers, viz.: the force of men and animals, weight, momentum, heat, chemical and electric action, &c. He says "Animal power cannot be used continuously; the fatigue consequent to this labour renders periodical repose indispensable, and an equal amount of work performed in a given period of time costs more by this means than by any other. The only advantage offered is that the work may be varied at pleasure, and a speed instantly produced vary from four to ten times the habitual velocity." Comparative tables are appended showing the amount of work, and the cost, obtainable from animal power of the descriptions most commonly in use, under different conditions, which cannot fail to be useful.

Strength of materials receives in the third division a considerable amount of attention, but our readers will, no doubt, acquit us of any charge of vanity when we say that the subject is much more fully treated upon in the exhaustive series of articles upon the subject, which will be found in the volumes of the Artizan for the years 1861-2.

The concluding portions of the book is devoted to descriptions of steam engines, hydraulic, and other machinery, which are fully and clearly described.

The work is illustrated with numerous wood engravings, and is accompanied (in a separate volume) by 52 plates of lithographic drawings, illustrative of the several subjects treated upon.

Taken as a whole, the *Guide pratique de l'Ouvrier Mécanicien* is a creditable production, and fully sustains the reputation of the eminent firm by whom it is published.

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*The Theory of Strains in Girders and Similar Structures; with Observations on the Application of Theory to Practice, and Tables of the Strength and other Properties of Materials.* By Bindon B. Stoney, B.A., Mem. Inst. C.E. In Two Vols. Vol. II., with Plates. London: Longman, Green, and Co. 1869.

The second volume of this work has just made its appearance. We noticed the production of the first volume in The Artizan for December, 1866. Mr. Stoney has completed his work in a thorough manner, and gives the results of experiments with various materials under different circumstances in such a form that the reader will think it scarcely possible to imagine any kind of strain the causes of which he has not illustrated. Flexure, crushing, buckling, bulging, and splintering, are the effects produced by undue strain upon various kinds of materials, and his hints must prove of the greatest utility to the engineer, the architect, the contractor, and the builder. The tensile strength and breaking strains of cordage, wire rope, and chains receive a special amount of attention, and since the Chain Cables and Anchor Act, 1864 (which continues in force until 1872) has rendered compulsory the submission of all chains and anchors to a proof-test similar to that required in Her Majesty's Navy, the attention of those interested in the matter has been aroused. The Act has certainly proved beneficial, and it will be a great loss to the mercantile community if it is not perpetuated. The work is admirably got up, and some features in the typographical arrangements greatly facilitate reference. We wish Mr. Stoney the success that his diligent labour deserves.

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*507 Mechanical Movements, embracing all those that are most important in Dynamics, Hydraulics, Hydrostatics, Pneumatics, Steam Engines Mill and other Gearing, Presses, Horology, and Miscellaneous Machinery.* By Henry T. Brown, Editor of the *American Artisan.* London: Trubner and Co. 1870.

A very neatly-executed edition, in small 4to., of the collections of mechanical motions, with which all must be familiar. All the old means of transmission and conversions of motions are given, together with some that are more modern, and quite novel in their application.

## CORRESPONDENCE.

*We cannot hold ourselves responsible for the opinions of our Correspondents.*

### STEAM BOILER EXPLOSIONS.

Sir,—The frequent bursting of steam boilers has induced me to send you the following copy of the letter I sent to the Secretary of the Board of Trade, after the accident on board the *Tonning* steam ship. I was then informed by Captain Robinson, the Surveyor-General at that time, that they had no power to insist on the masters of steam machinery to apply any other kind of safety-valve than that which has been in general use for many years, therefore, until the Government insists on all the owners of steam boilers having them tested and examined by a competent and independent engine surveyor, for land or water, we shall ever be hearing of steam boiler explosions, which are a disgrace to the country. The remark made by the coroner to the jury in the investigation of the bursting of the boiler of the steam-tug *Edward*, is equally applicable. With the present management of land boilers, little do we think of the danger we are exposed to when travelling by land or water.

I remain, Sir,
Your obdt. servant,
THOMAS SAMPSON.

(*Copy*).

Campden Hill Water Works, Kensington,
November 14th, 1860.

The Secretary, Marine Department, Board of Trade.

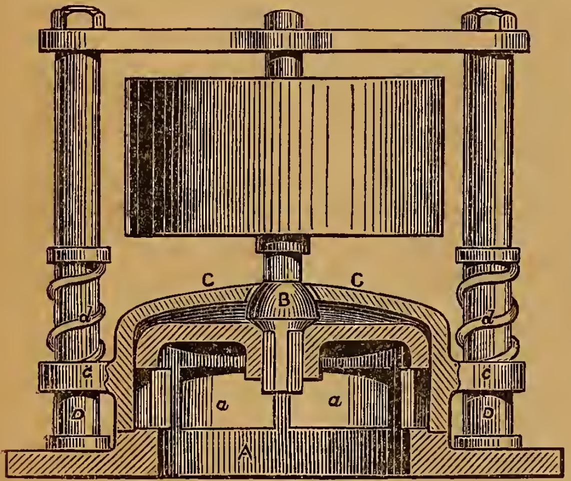
Sir,—The sad explosion which lately occurred on board the *Tonning*, steam vessel, has induced me to send you a few remarks for their Lordships' consideration. As the boilers of steam vessels in general are not constructed to sustain a very great pressure of steam over the working pressure, there should be introduced a self-acting safety valve, in addition to the valves now used, that should, if kept in good working order, act and prevent the steam from getting above the working pressure, without the assistance of engineers or foreman, under all circumstances. Mr. Tredgold, in his able work on the steam engine, observes that it would be a great improvement upon safety-valves if they could be so constructed as to be relieved of a part of their load when raised from their seats. Until something for this purpose is devised, I fear we shall always be liable to such accidents, and without showing any palpable neglect. At present the boilers are supplied with two valves, one under the control of the engineer, the other not: and those valves loaded according to the judgment of the surveyor, say, ten pounds per square inch. Suppose, now, the *Tonning*, or any other steam vessel, coming up Channel full speed, with fires in good working order, and the steam up, and the order should be given to the engineer to stop her to take in a few baskets of fish, he may think from this that it was not necessary to ease the safety-valves for such a short time, or should his attention be taken from this most important duty, he would in a few minutes find by the steam guage fifteen, instead of ten, pounds. This makes it evident that something, in addition to the present arrangement, is required. There are very often defects in marine boilers which cannot be seen by the engineer surveyor, and I could mention several similar accidents which have occurred on board of steam vessels, but as they did not all prove fatal, they were not brought under the notice of the Board of Trade.

I have a model of a self-acting safety-valve for the prevention of steam boiler explosions, for which invention I was awarded a prize by the Royal Polytechnic Society, in the year 1851. Should their Lordships feel so disposed, I should feel a pleasure in sending it for their inspection.

I remain, Sir,
Your most obdient and humble servant,
THOMAS SAMPSON.

## SAMPSON'S SAFETY-VALVE.

As the valve alluded to in letter of Mr. Sampson to the Secretary of the Board of Trade, appears to us to be very ingenious, we make no apology for giving an illustration of it, although it was invented several years ago.



The principle upon which this valve is designed, will be readily understood from the following explanation:—A is the body of the valve fitted in the usual manner to the steam chest of a boiler. This is provided with openings, *a*, *a*, round its circumference, and a small valve seat in the centre of its upper portion, upon which rests the weighted valve, B. An outer casing, C, is accurately fitted over the body, A, so as to close the openings *a*, *a*, perfectly steamtight. This casing is carried over the top of the body, A, to within a very short distance of the valve B, as shown in the accompanying engraving. The casing C is also provided with lugs, *c*, which slide on the guides, D; springs, *d*, being provided for the purpose of keeping the casing down when there is no pressure of steam to cause it to rise.

From the above description it is evident, that when the pressure of steam is only just sufficient to cause the weighted valve, B, to rise, it will blow off in the usual manner, but should this pressure increase it will cause this valve to rise so far as to close the opening in the casing, C. The immediate effect of this will be, to cause the steam to press against the top of this casing, and by thus forcing it up to allow the steam to escape through the openings *a*, *a*. As the area of opening thus provided is very great, ample facility for counteracting any sudden increase of steam is obtained. As soon as the pressure falls sufficiently to allow the small weighted valve, B, to close, the steam pressure is taken off the casing, and the small springs, *d*, *d*, instantly cause it to descend and shut the side openings.

The small valve, B, is here shown with a weight upon the top, but it may, of course, be weighted from the inside of the boiler, or with a lever in the usual way.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

A Mechanical Register of Distances.—The Council of the Society of Arts offer their silver medal for the best instrument, to be affixed to a cab or other hackney carriage, for indicating the fare as between the passenger and the driver, whether by registering the distance travelled otherwise, and which instrument shall also indicate, for the convenience of the cab owner and of the driver, the total distance travelled during the day and the total amount earned. The instruments competing with full descriptions of their construction, to be sent to the Society's house before January 1, 1870.

We learn from *Nature* that the Minister of Public Instruction has given orders for the construction of an agricultural map of France, on a novel plan. It will be built up of specimens of the various soils, arranged according to locality.

A California Gas Machine.—In a portable gas apparatus exhibited at the Fair of the Mechanics' Institute, at San Francisco, hydrogen gas is first generated by the immersion of iron filings in a dilute solution of sulphuric acid, the hydrogen being conveyed from the chamber where it is generated into a chamber below filled with gasoline, where it takes up its due proportion of carbon and is converted into a fixed carburetted hydrogen gas of high illuminating power. The apparatus is ingenious, and works automatically—making gas only when it is being used. Efforts are being made to introduce this gas into general use in San Francisco.

The Mechanics' Institute Exhibition of San Francisco closed on the evening of October 30. The receipts were over 61,000 dols.

### NAVAL ENGINEERING.

United States' Ironclad Fleet.—Our ironclad fleet, although somewhat diminished in numbers since the close of the rebellion, still presents a formidable bomb-proof *Flotilla* for coast defence, though somewhat rusty with age and hard knocks. Several of our best ironclads are fully manned and equipped, and could be ready at a moment's warning, while the entire lot could be sent along the coast inside of a fortnight, should such a necessity arise. To give our readers some idea of the numerical strength of our walls of iron, we append a list of the present position of the ironclads. Those with a star prefixed carry four guns, those with a dagger only one. The remainder carry two guns each, excepting the *Roanoke*, which has six. At League Island are lying the †*Achilles*, *Ætna*, *Argos*, *Atlas*, *Charybdis*, *Erebus*, *Goliath*, †*Gorgon*, †*Hydra*, *Jason*, *Lehigh*, *Medusa*, **Miantonomoh*, †*Nemesis*, *Niobe*, *Spitfire*, *Tartar*, and *Puritan*—17, and one hulk. At New Orleans, the *Ajax*, **Cyclops*, *Neptune*, **Sampson*, **Tornado*, and *Vesuvius*—6. At Mound City, the *Circe*, *Fury*, *Harpy*, *Hecate*, *Iris*, *Minerva*, *Tempest*, *Vixen*—8. At Washington, the *Castor*, †*Hero*, *Montauk*, and †*Orion*—4. At San Francisco ready for action, the **Monadnock* and *Comanche*—2. At the Naval Academy, the **Amphitrite*—1. In the North Atlantic Squadron, the *Centaur* and *Dictator*—2. At Boston, the *Terror*, ready for sea, and the *Eolus* and †*Stromboli*—3. At Philadelphia, the *Passaic* and *Scylla* ready for sea—2. The following vessels are in process of construction:—*Thunderer*, at Portsmouth; **Colossus*, at New York; **Hecla*, at Philadelphia; **Hercules*, at Boston; and the *Niagara* is being converted into a broadside vessel at Boston—5. The *Roanoke* with her three turrets is in ordinary at the Brooklyn Navy Yard—1. Total, 50. The torpedo boat *Spuyten Duyvil* is at the Brooklyn Naval Yard, and is a most terrible engine of warfare, not so much to look at as to encounter. It is not to be expected that a majority of these vessels could fight in a sea way; but as they were originally designed for coast defence, it is probable they would be assigned to such duty.—*New York Tribune.*

New Turret Ship.—On the 12th ult, the First Lord of the Admiralty, accompanied by Admiral Sir Sydney Colpoys Dacres, C.B., Mr. Reed, Chief Constructor of the Navy, Lieutenant-Colonel A. Clarke, C.B., Director of Admiralty Works, and Captain O. Willis, private secretary to Mr. Childers, arrived at Portsmouth, to lay the keel of a new ironclad turret ship, to be named the *Devastation*, a vessel of 4,406 tons, and of 800-horse power.

### SHIPBUILDING.

A new iron ship of war called the *Audacious* has arrived at Pembroke from Glasgow, under the command of Staff-Commander Spain. The *Audacious* was built by Messrs. Napier and Co., with engines of 800-horse power by Ravenhill and Hodgson. She has been sent to Pembroke for the purpose of being entirely sheathed over with teak wood, to prevent the action of the water on the iron. She is a fine vessel, and is a sister ship to the *Iron Duke*, now nearly ready for launching from Pembroke dock, of 3,464 tons burthen. The *Audacious* is on the twin-screw principle, and has two pairs of engines. On her passage to Pembroke, in a strong gale of wind, she averaged 11 knots.

Steam Shipbuilding on the Clyde.—Messrs. W. Hamilton and Co, have launched from their yard at Port Glasgow a wooden paddle, built to the order of Messrs. Theodoridi and Co., of Constantinople, for the Imperial Ottoman Government. The steamer, which has been named the *Amelia*, is the fourth which Messrs. Hamilton have built for the Turkish Government, and a sister ship is now in course of construc- British Government, has been towed down the Clyde and moored at the tail of tion in their yard. The Messrs. T. Wingate & Co., of Whiteinch, have launched a composite screw of 620 tons, fitted with a pair of improved compound surface-condensing engines of 100-horse power. The steamer, which has been named the *Wilhelmine Emma*, has been built to the order of Messrs. Miller Brothers, and she will proceed at once to Japan. The construction of the vessel is somewhat novel, the bottom being composite, with flush iron topsides, so as to combine in the highest degree the strength and stiffness of an iron vessel with the anti-fouling properties of a composite. Messrs. A. M'Millan and Son, of Dumbarton, have launched a screw of 600 tons; she has been named the *Eastern Isles*, and has been built to the order of a China and Japan house. Messrs. A. Stephens and Sons have launched the *Anglia*, built for Messrs. Handyside and Henderson's line of Transatlantic steamers, trading to New York. The *Anglia* is 2,100 tons burden, and is fitted with all recent improvements.

### TRIAL TRIPS.

Trial of H.M.S. "Rocket."—On the 12th ult., the gun vessel *Rocket* was taken out for the second time to the measured mile at the Maplin Sands, to try her boilers and machinery, the first trial having been very unsatisfactory. Upon this occasion the *Rocket*, which is sister ship to the *Thistle*, being of the same dimensions, steam power, and tonnage, and carrying the same number of guns, had an exceedingly narrow escape from an explosion. The trials were conducted by the officers of the Steam Reserve, and while the vessel was going at full speed on the mile the boilers primed to such an extent as to blow nearly all the water out of them, rendering it necessary to draw the whole of the fires. The alarm on board, especially in the engine-room and stokehole, was as may be supposed, very great, being naturally heightened by the remembrance of the calamity on board the sister vessel. Some of the men became so unnerved as to be obliged to go on deck; but others manfully remained at their duty, and by their exertions prevented another catastrophe. Various rumours are current as to the cause of the priming, but nothing positive has been made known. The fires were subsequently got up again, and the ship completed some of her trials.

### LAUNCHES

An ironclad frigate, the *Minine*, was launched at Cronstadt a few days back in presence of the Emperor of Russia, the Cesarewitch, the Grand Dukes Alexis and Constantine, and the Prince of Oldenburgh.

## RAILWAYS.

**North British Railway.**—At a meeting in Edinburgh, on the 12th ult., the chairman moved the approval of the Tay Bridge scheme, costing £350,000. An amendment was moved by Mr. Kinloch to delay the work for twelve months, but the chairman's motion was carried by large majority.

The Russian newspapers record the establishment of communication between Odessa and St. Petersburg by railway. The Emperor, arriving in his northern capital on the 25th October, made the journey in 66 hours—from which about eight hours must be deducted for necessary stoppages and for the crossing of the Dnieper near Kief.

A short time ago, at the York County Court, a cattle dealer obtained £40 damages from the North Eastern Railway Company, as compensation for injuries received by his beasts while in the railway trucks for conveyance between Howden and York.

A new station in the Uxbridge-road, a short distance on the London side of Shepherd's Bush was opened on the 1st ult. to the public. The Great Western trains from Kensington to the City will call at the new station.

The Brynmawr and Blaenavon Railway was opened for goods and mineral traffic on the 1st ult. The line connects the Blaenavon and other iron and coal works with the London and North-Western system, and will afford considerably increased facilities for the conveyance of traffic to the northern and midland districts.

The portion of the Lancashire Union Railway intended more directly to connect Liverpool with the manufacturing districts of Lancashire was opened on the 1st ult. for merchandise traffic, and by this additional link Liverpool will be brought into closer communication than it has hitherto been with the industrial portion of the county, more especially with the coal fields in the north-eastern districts. The new line joins the Lancashire and Yorkshire and also the London and North-Western Railways at their Wigan stations respectively. From Wigan the new line takes the direction of Chorley, which has hitherto been only brought into imperfect connection with the Lancashire railway system. It thence traverses a rich and densely populated mineral and manufacturing locality until it arrives at Blackburn, where, for the present, it will have its terminus, although the line is ultimately to be extended to the extreme part of the north-eastern division of the county.

## DOCKS, HARBOURS, BRIDGES.

**New Dock at Glasgow.**—A special meeting of the Clyde Trust was held on 10th ult, in Glasgow, the Lord Provost presiding. The committee appointed with regard to the new dock at Stobcross gave in a report as to the result of their negotiations. From this report it appeared that satisfactory terms had been arranged with the North British Railway Company and with the Stobcross proprietors; but with regard to Overnewton the price asked was an exorbitant one, and should not be acceded to. The committee recommended that the initiatory steps for getting Parliamentary sanction should be taken, and that, if no better terms could be come to, the lands of Overnewton should be acquired compulsorily under statutory powers. Mr. Bain, deputy chairman of the trust, in moving the adoption of the committee's report, stated that the proposed new dock would add 76 per cent. to the existing quayage of the harbour below the bridges. The estimated cost was £1,268,715, equal to £343 per lineal yard; but it was intended to make only 100 yards of the extension at a time, as the requirements of the trust demanded, and each section when made would be turned to profitable account. The report and its recommendations were unanimously adopted.

A steam travelling crane, supplied by Messrs. Taylor and Co., of Birkenhead, for use alongside No. 2 dock in Chatham Dockyard, to be used in the construction of the Sultan, has just stood a successful test. It was tried up to 17 tons, while it is required to lift only 15 tons; and acted very satisfactorily.

## TELEGRAPHIC ENGINEERING.

The directors of the West India and Panama Telegraph Company (Limited) have issued their report in anticipation of the meeting. They state that the manufacture of the cable is proceeding rapidly, 498 miles having been already completed to the entire satisfaction of the company's engineers, and it is anticipated that the greater part may be sent out by March next. A communication has been received from Sir Benjamin Pine, the Governor General of the Leeward Islands, expressing a desire that they should be included in the company's scheme, and negotiations are in progress for settling the terms.

The transfer of the telegraphs to the Post-offices in Ireland is to be deferred for a year, it having been found impossible to make the necessary arrangements in all the three kingdoms within the time previous to January 1st. For twelve months the business in Ireland will therefore be conducted in the existing offices, but under the control of the Postmaster General, to whose officers the revenue collected will be handed over.

## ACCIDENTS.

A Collision took place on the Western Pacific Railway, near San Francisco, on Sunday, November 14th. From ten to fifteen persons were killed, and from thirty to fifty wounded. The trains which came in contact were completely smashed. Great excitement has been caused in San Francisco by the accident.

On Wednesday last week the 1.30 p.m. train from St. Michel, an hour after commencing the ascent, ran off the line, and the engine fell across the rails after dragging the carriages within a few inches of the edge of a deep precipice. The passengers alighted, piled their luggage under the rocks, and waited till after midnight on the mountain before the engine was restored to the line and the train ready to make another start. The absence of the central rail at the point is the alleged cause of the accident.

## MINES, METALLURGY, &c.

**The Iron Trade.**—A special meeting of the ironmasters of South Staffordshire and East Worcestershire was held in Birmingham on the 4th ult. It was decided to advance the price of iron 20s. per ton, to raise the puddlers' wages 1s., and those of millmen, forgemen, and others, 10 per cent. Trade is decidedly better in the demand for finished iron.

**Zinc.**—The returns obtained from the zinc mines of the United Kingdom show a production in the year 1868 of 12,782 tons of zinc ores, principally sulphide of zinc (black jack,) the value being estimated at about £30,192. The number of mines was 35: 18 in England, 15 in Wales, one in Ireland, one in the Isle of Man. In England and Wales the chief production was from three counties: 3,350 tons from Denbighshire, 2,865 tons from Flintshire, 2,061 tons from Cornwall. 3,278 tons were produced in the Isle of Man. The production of metallic zinc was about 3,713 tons of the value of £75,436. All these figures are lower than those for the preceding year, 1867. Prices were lower in 1868 than in 1867 in the London market, the mean price of spelter falling from £21 6s. in 1867 to £20 6s. 4d. in 1868, and the mean price of zinc (in sheets) from £27 7s. 6d. to £25 13s. 4d. per ton.

## APPLIED CHEMISTRY.

It is stated that by melting copper in plumbago crucibles previously lined inside with pipe-clay and dried, non-porous castings may be obtained. As soon as copper, while in a molten state, is in contact with coal, or carbonaceous matter, it yields a porous and spongy casting.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 74 | 0 | 0 | 75 | 0 | 0 |
| Tough cake and tile do. | 73 | 0 | 0 | 74 | 0 | 0 |
| Sheathing and sheets do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bolts do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 81 | 0 | 0 | ,, | ,, | ,, |
| Old (exchange) do. | 65 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 73 | 0 | 0 | 73 | 10 | 0 |
| Wire, per lb. | 0 | 1 | 0 | 0 | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 8½ | 0 | 0 | 9 |
| Wire do. | 0 | 0 | 8 | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 10¼ | ,, | ,, | 11½ |
| Yellow metal sheath do. | 0 | 0 | 6½ | 0 | 0 | 7 |
| Sheets do. | 0 | 0 | 6½ | ,, | ,, | ,, |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 19 | 15 | 0 | 20 | 0 | 0 |
| Do. to arrive | 19 | 15 | 0 | 20 | 0 | 0 |
| ZINC. | | | | | | |
| In sheets, per ton | 24 | 0 | 0 | ,, | ,, | ,, |
| TIN. | | | | | | |
| English blocks, per ton | 123 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 124 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 130 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 112 | 0 | 0 | 114 | 0 | 0 |
| Straits do. | 114 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 2 | 6 | 1 | 3 | 6 |
| IX. do. do | 1 | 8 | 6 | 1 | 9 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 7 | 0 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 7 | 0 | 0 | ,, | ,, | ,, |
| Nail rods do. | 7 | 5 | 0 | ,, | ,, | ,, |
| Stafford in London do. | 8 | 10 | 0 | 9 | 0 | 0 |
| Bars do. do. | 8 | 7 | 6 | 9 | 0 | 0 |
| Hoops do. do. | 9 | 0 | 0 | 10 | 15 | 0 |
| Sheets, single, do. | 10 | 0 | 0 | 12 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 5 | 0 | 6 | 10 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 7 | 5 | 0 | 7 | 10 | 0 |
| Do. Swedish in London do. | 10 | 5 | 0 | ,, | ,, | ,, |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 15 | 0 | 3 | 2 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 6 | 0 | 0 | 6 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 0 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 5 | 0 |
| Do. in faggots do. | 15 | 15 | 0 | 16 | 0 | 0 |
| English spring do. | 19 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 18 | 17 | 6 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 5 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 10 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | ,, | ,, | ,, |
| Spanish do. | 18 | 7 | 6 | ,, | ,, | ,, |

*At the works 1s to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

### Dated October 23rd 1869.

3080 C. D Abel—Tiles and slates
3081 C. A. Ofverberg—Filters
3082 F. Woodward—Communicating on railway trains
3083 J. and J. Cash—Boxes or cases for preserving letters
3084 R. Scott and W. McIvor—Producing sulphate of soda
3085 F. S. Anderson—Obtaining fuel and light from water
3086 T. Deichmann—Preserving meat
3087 T. Hydes, and J. and J. E. Bennett—Propelling ships
3088 A. B. Ibbotson and T. S. Sarney—Securing railway rails
3089 T Bevington, S. Courtauld, and J. A. Norberg—Breaking stone
3090 L. Meurin—Clocks

### Dated October 25th, 1869.

3091 P. Walker—Rendering coal mines less injurious to those employed therein
3092 W. R. Lake—Needles
3093 W. R. Lake—Dry whitelead
3094 W. W. Ladalle—Bleaching
3095 J. H. Johnson—Adhesive compound
3096 G. Ireland—Nutcrackers
3097 J. Edge—Wire rope

### Dated October 26th, 1869.

3098 J. Lockwood—Couplings for railway engines and carriages
3099 W. B. Haigh—Saw benches
3100 J. S. Grierson and R. Philips—Illuminating cards
3101 T. Hoey—Fireplaces
3102 D. Spill—Preparation and use of solvents of xyloidine
3103 J. P. Rennoldson—Steam lubricators
3104 J. Dodge—Forging metals
3105 J. H. Nutt—Wrappers used in hydraulic and other presses
3106 J. Sheldon—Brushes

### Dated October 27th, 1869.

3107 T. Briggs—Materials used for packing and other purposes
3108 T. Dunn—Steam engines
3109 C. Simpson—Toy bricks
3110 W. A. Martin and E. Wylam—Consumption of smoke
3111 A. Bowater—Shaping metals
3112 J. Holding—Looms
3113 W. Llewellyn—Armour plating
3114 J. Wakefield—Bolts and pins
3115 O. L. Hopson—Reducing the diameter of wire for wire drawing
3116 T. Clark—Constructing tube wells and driving piles
3117 H. A. Bonneville—Box for enclosing photographic cartes
3118 W. R. Lake—Sheet iron
3119 W. A. Ross—Preserving iron and other metals from rust
3120 J. B. Elkington—Copper

### Dated October 28th, 1869.

3121 H. B. Barlow—Knitting machines
3122 R. Ventress—Saws
3123 J. Watson—Compressing cotton, jute, and other materials
3124 S. Bennett—Obtaining products from the waste of tanneries
3125 W. Brookes—Electro deposition of nickel
3126 J. W. More and J. Norman—Clipping horses &c.
3127 G. Tobbs—Buckles for doors
3128 L. P. Muirhead—Raising sunken ships
3129 F. T. Taylor—Drying and deodorising human excrement
3130 N. R. Vail—Axles
3131 W. E. Newton—Drawing frames
3132 S. C. Salisbury—Steam boilers
3133 M. Clemens—Shaft coupling

### Dated October 29th, 1869.

134 J. James—Bending and jointing metallic and other sheets
3135 A. Knowles—Getting coal
3136 W. W. Girdwood—Elastic packing
3137 W. R Lake—Springs
3138 T. Taylor and J. W. Davies—Singeing horses, &c.
3139 J. A. Miller—Steam generators
3140 C. D. Abel—Casting metal columns
3141 M., L., and E. Darnbrough—Lubricators for steam engines
3142 A. Nuirn—Steam carriages
3143 G. Borge—Cement
3144 B. J B. Mills—Cigars
3145 J. H. Spencer—Lubricating

### Dated October 30th, 1869.

3146 R. J. Everett—Salts of ammonia
3147 E. H. C. Monckton—Telegraphing
3148 J. Elce and W. J. Gradwell—Spinning and doubling
3149 O. Fahnehjelm—Cooking apparatus
3150 C. Sacre, S. Perkins, and W. Smellie—Iron
3151 J. C. Mewburn—Photographic process for preparing printed surfaces
3152 J. C Mewburn—Feeding boilers
3153 W. E. Gedge—Welding iron
3154 L. Wray—Engines
3155 A. P. Wright—Breaking, softening, and preparing flax
3156 R. Marsden—Raising weights
3157 T. Moore and C. A. Head—Raising and lowering weights
3158 W. B. Espeut—Drying machines
3159 A. Minton—Electro coating iron and other metals

### Dated November 1st, 1869.

3160 F. de Lagillardise—Suction syphons for raising liquids
3161 W. R Watson and R. Murray—Doubling yarns
3162 B. Bianchi—Cartridges
3163 J. Dewar—Treatment and application of paper waste
3164 J. Dewar—Artificial fuel
3165 E. Ford—Chromatic slides for cornets
3166 R. R. Addy—Preparing flax and other fibrous materials
3167 J. Hargreaves—Pyrites
3168 A. Thornton and B. Senior—Carding wool and other fibrous materials
3169 W. Birch—Sewing machines
3170 W. and J. Jackson and J. Cowgill—Preventing the escape of smoke
3171 J. Jenser—Guns
3172 B. Tower—Hot air engines

### Dated November 2nd, 1869.

3173 C. G. Gumpel—Ships' rudders
3174 R. Soice—Artificial stone
3175 G. White—Cartridges
4176 R. Davies—Machinery for transmitting motive power
3177 W. Connell—Waterclosets
3178 A. H. Brandon—Engines
3179 A. Wyllie—Bouuets
3180 C. E. Cawley and J. Newton—Tramways, and carriages for same
3181 J. P. Hawley and E. E. Hill—Controlling the flow of water

### Dated November 4th, 1869.

3182 S Leoni—Apparatus for cooking and lighting by gas
3183 A Grothe—Registering the number of persons travelling in public conveyances
3184 T. Wright and I. Fox—Production of piles on net or lace
3185 F. F. Snmier and A. Antoine—Preventing the explosion of inflammable materials
3186 H. J. H King—Regulating the passage or flow of liquids
3187 T. S. Martin—Stopcocks
3188 M. L. Winn—Shampooing
3189 N. W. Blanchard—Substitute for curled hair for upholstering
3190 E. Snell—Imitation marble
3191 J. McDowall—Sawing timber
3192 W. Gardner—Tools for the manufacture of watches
3193 G. Sinclair—Paper pulp
3194 E. Finch—Dock gates

### Dated November 5th, 1869.

3195 J. Booth—Reducing metals
3196 H. Wilde—Working telegraphs
3197 W. E. Gedge—Velocimanes
4198 M. Wilson—Sink traps
3199 S. Busk—Horseshoes
3200 C. de V. Wells—Regulating the speed of marine engines
3201 F. Armstrong—Sewing machines
3202 A. Russell—Making tucks or plaits
3203 E. Edmonds—Coffee pot

### Dated November 5th, 1869.

3204 C Crockford—Treating ores
3205 J. Maiden—Lubricators
3206 J. M. Starley—Furnaces
3207 J Turnbull—Cut off gears
3208 W. R. Lake—Needles
3209 J. K. Northall—Welding tubes
3210 F. Pash—Velocipedes
3211 A. M. Clark—Boring tools
3212 R. Douglas and L. Grant—Motive power engines

### Dated November 6th, 1869.

3213 F. Taylor—Sewing machines
3214 H. Livesey—Velocipedes
3215 W. R. Lake—Securing stair rods

### Dated November 8th, 1869.

3216 P. and A. Walker—Gas meter
3217 T. Perkins—Ploughing land
3218 N. Shaw—Generating steam and protecting furnace bars
3219 J. C. Heywood—Scales

### Dated November 9th, 1869.

3220 J. V. Michaux—Method or means of securing corks in bottles
3221 S. Heath—Machine for clipping horses and other animals
3222 R. Adera—Tinning metals
3223 R. Jones—General holder for cards, envelopes, &c.
3224 A. C. Kirk—Retorts
3125 G. D. Davis—Working rudders
3226 W. R. Lake—Heckling hemp
3227 T. Hattersley—Flyers used in spinning cotton, &c.
3228 C. Mola—Boots
3229 A. M. Clark—Transporting letters by atmospheric pressure

### Dated November 10th, 1869.

3230 J. and H. Tracey—Stick for umbrellas, parasols, &c.
3231 A. Bohlken—Terriers
3232 E. Thomas—Safety lamps
3233 W. Bonvaband—Weighing
3234 J. Riley—Roofs of buildings
3235 G. Knighton—Core barrels for making hollow castings
3236 F. Jenkin—Cables
3237 J. W. Hackworth—Slide valves for steam engines
3238 J. Ingleton—Waterclosets
3239 H. Lee—Looms
3240 F. B. Dœring—Stand or carriage for boring rocks
3241 I and G. Battinson and T. and H. W. Whitehead—Combing wool

### Dated November 11th, 1869.

3242 J. Logan and W. Gardner—Ornamenting fabrics
3243 A Masley—Lace machinery
3244 H. Robinson—Kilns for burning limestone, chalks, &c.
3245 T. Herbert and J. C Fowler—Railway signalling
3246 M Tuthill—Horse gear
3247 J. P. Budd—Iron
3248 J. McCormick—Brewing malt and other substances
3249 I. Nach—Sewing machines
3250 W. R. Lake—Locks
3251 J. Guesne—Organ and piano
3252 G. Simpson and L. Strauss—Drawing liquids from casks
3253 J. M. Rowan and T. R. Horton—Steam engines
3254 J. H Johnson—Producing ornaments from gutta percha
3255 J. Mason—Pens
3256 W. Harris—Locks
3257 P. Wilson—Locks and latches and in keys for same
3258 H. Rochatte—Breech loading firearms with central percussion
3259 G. A. Buchholz—Improved machinery for hulling grain

### Dated November 12th, 1869.

3260 M. Renson—Cleansing cracked wheat and other grain
3261 B. Shaw—Improvements in machinery for cutting soap
3262 S Martin—Supporting the rails of rail and tramways
3263 C. Brakell—Obtaining and applying motive power
3264 S. Chatwood and R. Kenyon—Improvements in furnaces
3265 O. Rose—Pistons for steam and other motive engines
3266 G. D. Edmeston—Hammers worked by steam, &c.
3267 W Gorman—Iron and steel, and in apparatus therefore
3268 T. Snow—Exhibiting notices at railway stations
3269 W. E and F. Dobson—Shawls made on lace machines
3270 S. W. Shaw—Burning Bricks
3271 H. R. Mines—Improvements in letter pillar posts

### Dated November 13th, 1869.

3272 G. H. Hannaford—Working railway points and signals
3273 J. Edwards—Permanent way of railways, and signals on same
3274 W. E. Gedge—Preserving metal from the effects of humidity
3275 W. E. Gedge—Cutting and shaping wood and metals
3276 C. H. Holt—Obtaining blast in smelting furnaces
3277 R. Hardman and G. Hardman—Carding engines
2378 C. Burgon and J. Ball—Manufacture of sheep
3278 R. Smith and J. Higginbottom—Paper hangings
3280 C Sutton—Ascertaining the presence of certain bodies concealed from view
3281 T. A. Dillon—Safety lamp
3282 W. Richardson—Valves of steam engine cylinders
3283 H. H. Grierson and J. M. Rigby—Dressing stone
3284 J. Henderson—Treating ores and obtaining products therefrom
3285 C. D. Saiotgnot and C. Poucel—Preventing incrustation in boilers
3286 R. Gaothony—Improved inking or stamping pad

### Dated November 15th, 1869.

3287 P. Kosh—Knobs or handles of locks, doors, &c.
3288 W. E. Gedge—Box for matches and other purposes
3289 F. Clarbour and W. E. Teale—Improvements in lamps
3290 F. Brampton—Locks
3291 F. Clark—Machinery for the manufacture of bricks
3292 C. D. Abel—Process for refining and desilvering lead
3293 J. Tribe and J. Mallett—Despatch and other boxes
3294 A. Jngla—Glaves
3205 W. Gossage—Obtaining a compound of soda, &c.
3296 H. A. Bounsville—Clipping horses and other animals
3297 G. R. Muther—Cutting or giving form to wood
3298 J. G. Jones—Breaking down coal

### Dated November 16th, 1869.

3299 G. Cherpit—Healds for looms
3300 W. H. Tucker—Locks
3301 W. Lancaster—Furnaces for steam boilers and other purposes
3302 M. W Srigley—Friction engine for producing motive power
3303 M. Santter—Shells
3304 H. H. Violet—Stoppers
3305 C. Ashbury—Steam boilers
3306 J. G. Garrard—Buffers adapted to railway carriages
3307 W. Neill—Blast engines
3308 J. Oppenheimer—Fixing and staying telegraph posts
3309 F. Delacroix—Manumeter
3310 C Ching—Hot water boilers for supplying baths

### Dated November 17th, 1869.

3311 P. Negrin—Regulating the flow of liquids through pipes
3312 S. J. Mackia—Construction and propulsion of vessels
3313 J. Crofts, R. Dawson, and J. King—Combing wool
3314 T. Marshall—Preventing the fouling of ships' bottom
3315 T. and H. Weston—Casing metallic tubes and rods
3316 J. Willis—Umbrellas
3317 E. Bazing, A. Ruiz, and E. Le Polletier—Looms
3318 W. H. Perkin—Colouring matter suitable for dyeing

### Dated November 18th, 1869.

3319 R. Ogden—Deodorising coffins having dead bodies in them
3320 G. R. Sweetser and G. Wadman—Working wood
3321 G. B. D'Adelsward—Taking the dross out of high furnaces
3322 Meters
3323 E. Karting—Feeding boilers
3324 C. Faure—Galvanic batteries
3325 J. P. Kerr and W. McGee—Winding thread upon pirns
3326 G H. Kenworthy and T. Knowles—Preparing cotton
3327 M. Shelley—Vent peg
3328 H. A. Hammond—Chimney cowl
3329 G. Petrie—Bricks
3330 T. Llewellyn—Squaring wood

### Dated November 19ht, 1869.

3331 S. Mendel—Packing cotton
3332 J. Dackray—Drying and finishing threads and cords
3333 J. Hartley and Z. Sugden—Boilers for hot
3334 T. E. Lundy and J. L. Dunham—Communication between passengers and drivers
3335 G. F. Cornelius—Paint
3336 R. Ciews—Weaving
3337 R. K. Miller and A. B. Herbert—Pumps
3338 J. Orson—Goffering and plaiting textile fabrics
3339 W. N. MacCartney—Railway carriage for passengers
3340 W. and M. Bayliss—Screws
3341 A. M. Clark—Battery gun
3342 I. Hayford and J. F. Paul—Wooden pavements for streets
3343 W., J. and F. W. Edmondson and R. Cunliffe—Engraving cylinders

### Dated November 20th, 1869.

3344 C. D. Abel—Utilising streams as motive power
3345 J. Cochrane—Conveying letters by pneumatic agency
3346 H. Wilson—Lubricating apparatus for steam engines
3347 G. Betti—Vertical boiler for the formation of steam
3348 L. Follhet—Grease box
3349 J. Taylor—Furnaces
3350 J. Belicard—Manufacture of metal healds for weaving
3351 T. Aitken—Washer cloth for spinning machinery
3352 W. Temlett—Banjos
3353 T. R. Hetherington—Preparing cotton
3354 D. Morgan—Lubricating oil
3355 T. F Lynch—Bottles
3356 S. H. Salmon—Shearing horses
3357 A. B. Childs—Cleaning grain
3358 W. R. Lake—Distributing type
3359 J. H. Fraser—Boilers
3360 S L. Loomis—Sash holder
3361 Sir J. Macneill—Surfaces for igniting lucifers and fusees
3362 J. Moseley—Warming feet
3363 J. Burroughs—Electro-magnetic machines and magnets for the same

### Dated November 22nd, 1869.

3364 R. Wilson—Presses
3365 S. W. Wilkinson and J. E. Dooley—Portable letter boxes
3366 G. H. Wilkes—Supporting clothes lines
3367 J. Bourne—Gauging water in boilers
3368 J. Bottomley and S. Emsley—Spinning
3369 J., J., and H. Ingham and C. Smith—Shuttles for weaving
3370 R. Hennell—Pavements
3371 Fire-escapes

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